UNITED STATES OF AMERICA

NATIONAL TRANSPORTATION SAFETY BOARD

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In the matter of:                       *
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INVESTIGATION OF THE ASIANA AIRLINES    *
FLIGHT 214 LANDING ACCIDENT AT          * Docket No. DCA-13-MA-120
SAN FRANCISCO INTERNATIONAL AIRPORT,    *
CALIFORNIA, JULY 6, 2013                *
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Board Room and Conference Center
National Transportation Safety Board
429 L'Enfant Plaza, S.W.
Washington, D.C. 20694

Wednesday,
December 11, 2013

The above-entitled matter came on for hearing, pursuant to Notice, at 8:30 a.m.

BEFORE: BOARD OF INQUIRY

APPEARANCES:

NTSB Board of Inquiry

DEBORAH A.P. HERSMAN, Chairman
CHRISTOPHER A. HART, Vice Chairman
MARK R. ROSEKIND, Ph.D., Member
ROBERT L. SUMWALT, Member
EARL F. WEENER, Ph.D., Member

NTSB Staff

BILL ENGLISH, Investigator-in-Charge
TIMOTHY LeBARON, Hearing Officer

Technical Panel

WILLIAM BRAMBLE, Ph.D., NTSB
ROGER COX, NTSB
JOHN DeLISI, NTSB
BILL ENGLISH, NTSB
EMILY GIBSON, NTSB
TIMOTHY LeBARON, NTSB
JEONG-KWEN PARK, Korean Aviation and Railway Accident Investigation Board (KARAIB)
PETER WENTZ, NTSB

Interested Parties

CAPT. SEUNG-YOUNG KIM, Executive Vice President, Operations, Asiana Airlines
CAPT. SUNG-SIK MIN, Chairman, Asiana Pilots Union (APU)
JOHN O'DONNELL, President, Air Cruisers
ROB HENTGES, Boeing Program Manager, Air Cruisers
MICHELLE BERNSON, Chief Engineer of Safety Investigation, Boeing Company
TRYG McCOY, Chief Operating Officer, San Francisco International Airport, City and County of San Francisco
BOB DRAKE, Office of Accident Investigation, Federal Aviation Administration (FAA)

APPEARANCES (Cont.):

Panel 1: B777 Flight Deck Design Concepts and Characteristics

STEPHEN BOYD, Federal Aviation Administration (FAA), Acting Assistant Manager, Transport Airplane Directorate
CAPT. JOHN CASHMAN, Boeing (Retired), Former B777 Chief Pilot
ROBERT MYERS, Boeing, Chief Engineer of Flight Deck Engineering

Panel 2: Asiana Pilot Training on B777 Automated Systems and Visual Approach Procedures

JAMES "MIKE" EITEL, FAA, Aviation Flight Inspector, Chairman of FAA AEG Flight Standardization Review Board for B777
CAPT. DAREN GULBRANSEN, Boeing Manager, Flight Training - Simulator
KWANG-HEE LEE, Director, Air Operations Safety Division, Korean Office of Civil Aviation (KOCA)
CAPT. SUNG-KIL LEE, Asiana Airlines, B777 Chief Pilot
CAPT. ROD McNAUGHTON, Cambridge Communications Ltd., Manager Flight Training - Boeing Korea
CAPT. BYEONG-GEOUN YOO, Asiana Airlines, Training Manager

Panel 3: Effects and Influence of Automation on Human Performance in the Accident Sequence

KATHY ABBOTT, Ph.D., FAA, Chief Scientist and Technical Advisor for Flight Deck Human Factors, Co-Chair of the Performance-based Operations Aviation Rulemaking Committee/Commercial Aviation Safety Team (CAST) Flight Deck Automation Working Group
STEPHEN BOYD, FAA, Acting Assistant Manager, Transport Airplane Directorate
CAPT. DAVE McKENNEY, IFALPA, Co-Chair of the Performance-based Operations Aviation Rulemaking Committee/CAST Flight Deck Automation Working Group
BOB MYERS, Boeing, Chief Engineer of Flight Deck Engineering
NADINE SARTER, Ph.D., University of Michigan, Academic Expert on Automation and Human Performance

APPEARANCES (Cont.):

Panel 4/5: Emergency Response, Airplane Cabin Crashworthiness and Occupant Protection

MIKE O'DONNELL, FAA, Director, Office of Airport Safety and Standards AAS-1
DALE CARNES, Assistant Deputy Chief, San Francisco Fire Department
JOHN SHIVELY, Oshkosh Corp., Senior Chief Engineer, Airport Products
MARC TONNACLIFF, FAA, Aircraft Rescue Fire Fighting (ARFF) Specialist
DAVID WHITAKER, Chief (Retired), ARFF Working Group
RICHARD DeWEESE, FAA, Civil Aerospace Medical Institute, Biodynamic Research Team Coordinator
JEFF GARDLIN, FAA, Aerospace Engineer, Transport Airport Directorate
JOHN O'DONNELL, President, Air Cruisers
BRUCE WALLACE, Boeing, Evacuation Systems Engineer, Associate Technical Fellow

I N D E X

I N D E X (Cont.)

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P R O C E E D I N G S

(8:35 a.m.)

CHAIRMAN HERSMAN: Good morning. I am Debbie Hersman, Chairman of the National Transportation Safety Board. I am joined by my fellow Board Members: Vice Chairman Chris Hart, Member Robert Sumwalt, Member Mark Rosekind and Member Earl Weener.

During this investigation, we are working closely with NTSB's Korean counterpart, the Korean Aviation and Railway Accident Investigation Board, or the KARAIB. We welcome Chairman Tae-hwan Cho, as well as other KARAIB leaders and staff who are in the audience today. Chairman Cho, if you will rise. Nice to see you. Thank you for being here.

I also thank Jeong-kwen Park, the Accredited Representative from KARAIB, who also will serve on this hearing's technical panel. Finally, I would like to recognize our friends who are here today from China's CAAC; France's BEA; and the Netherlands' DSB. These are our counterpart agencies around the world. We welcome you to this hearing.

Today's hearing will address the first fatal commercial airline crash in the United States since February 2009. It is a testament to the steadily improving safety of commercial aviation that almost 4½ years, and more than 40 million flights, have passed between the Colgan crash near Buffalo, that claimed 50 lives and the one that we discuss today. But yet, sadly, we do meet today, we meet to learn lessons from the crash of the Asiana

Airlines Flight 214 event at San Francisco International Airport.

On July 6, 2013, Asiana Flight 214, a Boeing 777-200ER with 291 passengers, 12 cabin crew, and 4 flight crew aboard, struck a seawall during approach to the airport. The tail cone, vertical and horizontal stabilizers, part of the landing gear, and the aircraft's two engines were separated from the plane during the accident sequence, while the aircraft rotated 330 degrees before coming to rest a couple thousand feet down the runway. The post-crash fire was initiated when oil came into contact with the right engine, which remained in close proximity to the fuselage and ignited.

The accident resulted in 3 fatalities, and more than 200 passengers and crew were transported to local area hospitals. On behalf of my fellow Board members and the entire NTSB staff, we offer our condolences to those who lost loved ones and extend our sincere wishes for those who were injured to achieve a full recovery. I know several of you are viewing these proceedings from San Francisco or may be watching from your homes. We recognize that your lives were forever changed when the crash occurred, and we know that nothing can replace the loss of your loved one or repair the trauma of a life-changing injury. But we do have the opportunity today to ensure that the lessons of this event are well-learned and that the circumstances are not repeated.

And despite damage which might have resulted in scores or hundreds of fatalities, more than 300 passengers and crew survived. In this hearing, we will learn about the facts of the crash, but we will also learn about the factors that enabled so many to walk away. We will focus not only on the human-machine interface in highly automated aircraft, but also on emergency response and cabin safety.

Last week, on December 5, 2013, the NTSB conducted a pre-hearing conference attended by NTSB's personnel and parties to this hearing. At the conference, we delineated the issues to be discussed at this hearing and identified and agreed upon the list of witnesses and exhibits.

The five broad issues that we will discuss today are:

1. Boeing 777 flight deck design concepts and characteristics;

2. Asiana pilot training on Boeing 777 automated systems and visual approach procedures;

3. Effects and influence of automation on human performance in the accident sequence;

4. Emergency response; and

5. Airplane cabin crashworthiness and occupant protection.

Testimony and questioning will be limited to these five issues.

Before proceeding, I'd like to identify the NTSB staff members who are part of this hearing. First, Mr. Bill English, our Investigator-in-Charge; Tim LeBaron, the Hearing Officer.

Our technical panelists include Dr. Bill Bramble, Roger Cox, John DeLisi, Emily Gibson, and Pete Wentz, and from the KARAIB, Mr. Jeong-kwen Park.

Additional support is provided by NTSB staffers, Keith Holloway, who is in the back handling Public Affairs; Mr. David Tochen, who is seated behind me; Mr. Jim Rodriguez and Mr. Benjamin Allen who will all provide legal support. Adam Huray and Andy Olvis are in the back row, and they will supporting our team with the audio/visuals.

I would also like to take a moment to thank Hyoo Choi, who acted as a liaison between the NTSB and KARAIB in preparation for this hearing over the last couple of months.

I will now introduce the parties designated to participate in the investigative hearing. As prescribed in the Board's rules, we designate as parties those persons whose participation we deem necessary in the public interest and whose special knowledge will contribute to the development of pertinent evidence. As I call the name of the party, I ask the designated spokesperson to identify themselves and their affiliation with the party they represent and introduce the other persons at their party's table.

We'll begin with Asiana Airlines, Capt. Seung-young Kim.

CAPT. KIM: Good morning, Chairman Hersman, Vice Chairman Hart, other Members of the Board, and ladies and gentlemen. My name is Capt. Seung-Young Kim. I'm Executive Vice President of Flight Operations at Asiana Airlines, and I am Asiana's party representative for today's hearing.

Let me begin by expressing our general sorrow for the loss of life and the injuries sustained by passengers on Flight 214. To the passengers who were injured and to the families who lost their loved ones, we are deeply sorry.

We at Asiana are committed to doing everything we can to prevent such an accident from ever happening again. We appreciate the NTSB's work in investigating the causes of this accident, and we are grateful for the opportunity to participate in the investigation and in today's hearing.

With me today are Ms. Mi-Hyung Kim, Executive Vice President of Asiana; Capt. Il Jae Park, Vice President of Safety and Security; Capt. Moon Sik Yim, CRM instructor; Mr. Daniel Suleiman, outside counsel; and Ms. Chris Tang, also outside counsel. Thank you.

CHAIRMAN HERSMAN: Thank you, Capt. Kim.

We'll now move to Asiana Pilots Union, Capt. Sung-Sik Min.

CAPT. MIN: Yes, Madam Chairman. My name is Capt. Min. I am the chairman of the Asiana Pilot Union. Seated to my right is First Officer Kim, Boeing 777 safety representative for Asiana Pilot Union. To First Officer Kim's right is First Officer Shin, a safety representative for ALPA Korea. Across from me is Chad

Balentine, senior staff engineer for ALPA International. Next to Mr. Balentine is Capt. Paul McCarthy, retired Boeing 777 captain from IFALPA. Next to Capt. McCarthy is Capt. Coetzee, Executive Vice President for Professional Affairs for IFALPA. Thank you, Madam Chairman.

CHAIRMAN HERSMAN: Thank you, Capt. Min.

We'll now move to Air Cruisers, Mr. John O'Donnell.

MR. O'DONNELL: Good morning, Madam Chairman. My name is John O'Donnell. I'm president of Air Cruisers. To my left is Ed Vienckowski. He's technical director. Across the table from me is Rob Hentges. He's the Boeing program manager for our products. Thank you, Madam Chairman.

CHAIRMAN HERSMAN: Thank you.

The Boeing Company, Ms. Michelle Bernson.

MS. BERNSON: Good morning, Madam Chairman. Boeing would also like to express its condolences to the families who lost loved ones in this accident, and it's sympathy and wishes for a speedy recovery to those injured.

This morning, at our table we have myself, Michelle Bernson. I'm the chief engineer of air safety investigation. Across from me is Larry Schneider. Larry's the chief project engineer for the 777 airplane. Next to me is Mark Smith. Mark is one of our air safety investigators and was the air safety investigator for Boeing on scene. Across from Mark is Allison Kendrick. Allison is our principal senior counsel for the Boeing

Company. We also have Gary Meiser who is our chief project pilot for the 777 airplane, and Bruce Campbell, who is our partner at Perkins Coie. Thank you very much.

CHAIRMAN HERSMAN: Thank you.

The City and County of San Francisco, Mr. Tryg McCoy.

MR. McCOY: Good morning, Madam Chairman. My name is Tryg McCoy. I'm the Chief Operating Officer of San Francisco International Airport. I'd like to introduce the people here at our table. Across from me is Counsel Gary Halbert. Next to him is Assistant Deputy Chief Dale Carnes of San Francisco Fire Department assigned to San Francisco Airport. Next to him is Constance Menefee from the General Counsel. Across from her is Mr. Doug Yakel, Principal Information Officer, San Francisco Airport. And next to me is Ms. Sheryl Bregman, General Counsel, San Francisco International Airport.

CHAIRMAN HERSMAN: Thank you, Mr. McCoy.

And finally, the Federal Aviation Administration, Mr. Bob Drake.

MR. DRAKE: Good morning, Madam Chairman. Bob Drake with FAA's Office of Accident Investigation. To my right is Tony James, also with FAA's Office of Accident Investigation, our on-scene investigator. Across from me is Paul Berenato. He's with the FAA's Seattle Aircraft Certification Office. And Andrew Dilk, who is with FAA's Office of General Counsel.

CHAIRMAN HERSMAN: Thank you, Mr. Drake.

I'd like to thank all of the parties for their cooperation with the investigation thus far.

I'd like to especially thank all of the parties, the witnesses, and everyone in attendance for your willingness to be accommodating. We have a long schedule today due to the weather delay yesterday. Thank you for everyone who has been willing to adjust your schedules and to make your witnesses available. We look forward to having a productive day. And I know it will be a long one, but we'll make sure that we have a number of breaks in here.

So thank you all for your cooperation with the investigation thus far. We still have a lot of work before we get to the end of this investigation but we do appreciate your valuable time and we look forward to working with you as this investigation proceeds.

We will begin this hearing with a presentation by the Investigator-In-Charge, Mr. Bill English, who will provide an overview of the crash. We will then proceed in sequence, one panel at a time for each hearing issue. You all should have copies of the revised hearing agenda for this 1-day hearing, that will run until 8 p.m. this evening.

For each panel, the Hearing Officer, Mr. LeBaron, will call and introduce the witnesses, and each witness will testify under oath. The witnesses have been pre-qualified and their qualifications and biographical information are available on the

NTSB website.

The witnesses will be questioned first by the NTSB's technical panel, then by a spokesperson from each of the parties, and finally by the Board of Inquiry. We will ask the parties to limit their questions to 5 minutes per panel, and because of the compressed schedule, the Board Members will do the same. After one round of questions, due to time constraints, a second round will be limited to pertinent questions that serve to clarify the record or address some new matter raised.

I must again emphasize the fact-finding nature of the hearing. NTSB investigations are, by regulation, fact-finding proceedings with no adverse parties. The Board does not assign fault or blame for an accident or incident.

At this hearing, witnesses may not speculate or analyze the facts, and questions are limited to the predetermined subject matter of the hearing, which is contained in the hearing agenda. Questions related to fault, outside litigation, legal liability, or cause of or manner of death, will not be permitted.

The exhibits include redactions, noted with an opaque box, which were the result of negotiations between the parties and the NTSB regarding claims of the disclosure of proprietary and personally identifiable information. The NTSB is authorized by statute to disclose information to carry out its duties, but we must do so in a way that protects confidentiality to the greatest extent possible.

At this time I will call on the Hearing Officer to go over a few items. Mr. LeBaron.

MR. LeBARON: Thank you, Chairman Hersman.

I'd like to start by covering a few household items, excuse me, housekeeping items.

First of all, let's talk about safety. In the event of a fire alarm, there are several ways to exit the Conference Center. You may exit to the outside by departing the back of the auditorium and continuing to walk straight, passing through two sets of glass doors. There are additional exits here in the front on either side of the Board Member podium.

If an emergency arises and someone needs emergency attention, please notify one of the security guards located at the entrance of the Conference Center.

Let's talk about breaks quickly. Today our first break will begin at 9:50 a.m. We will then have an hour lunch break starting at 11:15 a.m., an afternoon break around 2:10 p.m., and then a 50-minute dinner break starting at 4:25 p.m. We plan to conclude the hearing by 8 p.m. this evening.

With respect to microphones, when speaking be sure to move the microphone close to you and switch it on by pushing the small button on the base. Be sure to switch the microphone off when you are done speaking to prevent interference.

As the Chairman stated, the investigative hearing is being broadcast in three languages: Korean, Mandarin and English.

There's also an remote electronic transmission site in San Francisco available for passengers of the flight and their families. Interpreters are on site here in the Conference Center and will require a constant audio feed to conduct their work for local attendees, for the webcast, and for the remote transmission.

When speaking, please pull the microphone close, enunciate clearly, speak slowly, and make your questions short and concise to ensure optimal sound quality for the broadcast and for precise translation.

Moving on to exhibits. The exhibits entered into the record and any presentations along with other records of the investigation become part of the NTSB public docket and are available via the NTSB website, which is www.ntsb.gov.

A transcript of the testimony taken during the hearing will be prepared and entered into the docket as soon as practicable.

The parties to the hearing will have the opportunity to submit proposed findings to be drawn from the testimony and exhibits, a proposed probable cause, and proposed safety recommendations designed to prevent future accidents. The proposals will be made part of the public docket and will receive careful consideration during the Board's analysis of the evidence in preparation of the final report.

I encourage the parties to the hearing to make use of this opportunity. Please note that the proposals must because received by the NTSB within 30 calendar days of the NTSB's transmittal of the draft hearing transcript and copies must be provided to each of the parties to the hearing.

The hearing transcript should be available to the parties by December 18, 2013. Thus, submissions are due by January 18, 2014.

Chairman Hersman, this is all I have at this time.

CHAIRMAN HERSMAN: Thank you, Mr. LeBaron.

Mr. English, will you now provide an overview of the accident for the group?

MR. ENGLISH: Thank you, Madam Chairman. Good morning.

On July 6, 2013, at 11:28 local time, a Boeing 777 operated by Asiana Airlines as Flight 214 struck the seawall short of Runway 28-Left at San Francisco International Airport. The airplane was destroyed by impact forces and fire.

Three of the 291 passengers were fatally injured, and approximately 199 were transported to hospitals with injuries. Three of the 4 flight crew and 10 of the 12 cabin crew members were injured.

The flight was a regularly scheduled passenger flight from Seoul, Korea operated under the provisions of 14 CFR Part 129.

The departure and end route portions of the flight were routine. Flight time was approximately 10.5 hours. The airplane entered the San Francisco Terminal Area at approximately 11:15

local time via a standard arrival route. The weather at the time was clear with light winds from the south/southwest.

The flight was vectored for a visual approach to Runway 28-Left. The glide slope portion of the instrument landing system was out of service due to a runway construction project and the pilots were aware of that information via a FAA Notice to Airmen.

The pilot flying in the left seat was a captain transitioning from the Airbus 320 to the Boeing 777 and had a total time of about 9700 hours and less than 45 hours in the 777. This was his first trip in San Francisco in that type of aircraft. His last flight to San Francisco was in 2004 in a Boeing 747.

The pilot monitoring in the right seat was an instructor pilot, newly certified as an instructor, with a total time of about 12,000 hours and approximately 3200 hours in the Boeing 777. He had been into San Francisco many times recently.

One of the two relief first officers was seated in the jump seat.

To help understand the sequence of events, here is a view of the left side of a 777 panel. The pilot's primary flight display, or PFD, is on the lower left of the screen and zoomed in above right. The top of the PFD contains the flight mode annunciation, or FMA, area, which shows the current autothrottle roll and pitch modes. Airspeed is displayed on the vertical tape on the left side of the PFD, and altitude and vertical speed on the right side.

The mode control panel, or MCP, where the pilot makes entries to the autoflight system is on the glare shields, circled here. Entries to select desired airspeed, altitude, vertical speed and heading are made on this panel. It also includes switches to select the various autopilot flight director system, or AFDS, modes. Autopilot and autothrottle disconnect switches are also located on the control yoke and throttles, respectively.

Please note that these graphics are for demonstration only and do not necessarily reflect the exact status of the accident airplane.

After reporting the airport in sight, the flight was cleared for a visual approach on a 14-mile straight-in final. ATC instructed the crew to maintain 180 knots until 5 miles from the airport, and there was no altitude restriction imposed.

In this next sequence of slides, you will see imaginary lines for viewer reference relative to the normal glide path extending from Runway 28-Left, as well as mode control panel entries and status in the brown box, flight mode annunciation status in the black box, and the airspeed and altitude from the primary flight display in the dark blue box.

As the airplane passed over the Dumbarton Bridge, descending through about 4,800 feet on the extended centerline of the runway, indicated airspeed was 210 knots, descent rate was about 1300 feet per minute. The AFDS was configured such that the autopilot was engaged and selected to flight level change mode descending to a selected altitude of 1,800 feet, which was the normal final approach fix, or FAF, altitude. The autothrottle was engaged in hold mode with the thrust levers at idle. This is an expected configuration to descend to FAF altitude.

Shortly after, the crew switched the autopilot to vertical speed mode with a commanded descent rate of 1,000 per minute and the autothrottle switched to speed mode with a selected airspeed of 172 knots. That rate of descent was not fast enough to remain on the normal glide path and the airplane diverged above the normal angle. Landing gear was extended and the descent rate was briefly selected to 1,500 feet per minute, then back to 1,000. At this point, the airplane was about 6 miles from the runway at about 175 knots and descending through 2,400 feet, well above glide path.

As the airplane approached the San Mateo Bridge, which is about at the FAF or 5-mile point, the MCP select altitude was changed to 3,000 feet to prepare in case a go-around is needed, which is a normal action on approach. Shortly afterward, the airspeed select was set to 152 knots. The airspeed was still well above the desired glide path.

At an altitude of about 1600 feet and 3.5 miles from the runway, data indicates the flight level change switch on the mode control panel was activated changing the autopilot and autothrottle operating mode. Flight level change is an autopilot mode normally used to climb or descend to selected altitudes during the climb-out, cruise, and initial descent phases of flight. It is not recommended to use flight level change past the final approach fix according to the Boeing Flight Crew Training Manual.

As a result, the AFDS began to command a pitch up and power increase as it attempted to climb the airplane to 3,000 feet at 152 knots, as had been previously selected on the MCP. The pilot responded by disconnecting the autopilot and manually retarding the throttles to idle.

In this configuration the autopilot was not commanding the airplane, but the system made inputs to the flight directors in flight level change mode. The autothrottles transitioned to hold mode with the thrust levers at the idle position due to the manual override. These modes were annunciated on the FMA, as you see here. In this configuration the autothrottles would not be controlling airspeed.

However, the airspeed select was then changed to 137. At about 5 seconds later, flight recorder data showed that the left side flight director was switched off but the right side remained on.

About 1.4 miles from the runway and 500 feet altitude, the airplane descended through the normal glide path and was passing through the desired speed of 137 knots but rapidly decelerating.

On this slide, I've removed the MCP graphic as no further changes are made and to better show the precision approach path indicator, or PAPI, light graphic by the runway.

The pitch attitude steadily increased as the pilot applied back pressure to the column to attempt to maintain the glide path per the PAPI indicators, but there was no mention of the decaying speed on the cockpit voice recorder at this time. Thrust levers remained at idle as the airplane continued to lose airspeed and sink below the glide path.

Twenty-four seconds from impact, the airplane was about .9 miles from the runway and 300 feet altitude. The airplane continued to descend well below the PAPI glide path, as indicated by the four red lights, decelerating through 120 knots and at a pitch attitude of about 7 degrees nose up.

About 11 seconds prior to impact, an audible alert consistent with the low airspeed caution was recorded. Three seconds later, just below 100 feet above the water, the throttle levers were moved fully forward to initiate a go-around, followed 4 to 5 seconds later by stick shaker activation and a verbal call to go around. But the action was too late and the main gear and underside of the aft fuselage struck the seawall.

The lowest recorded airspeed was 103 knots, which was about 34 knots below the desired airspeed.

Due to the potentially disturbing nature of the surveillance video we are about to show, we will pause for a moment to let attendees exit the room if they choose.

Go ahead.

(Surveillance video played.)

The tail of the aircraft broke off at the aft pressure bulkhead. The airplane slid along the runway before the fuselage lifted into an approximately 30-degree nose-down angle and pivoted about 330 degrees before coming to rest off the left side of the runway.

Evacuation of the airplane was initiated by passengers and crew. Fire initiated within the right engine which was adjacent to the right side of the fuselage and penetrated into the cargo compartment and cabin and eventually vented through the airplane roof.

Two slide rafts inflated within the cabin during the impact sequence temporarily trapping and injuring two flight attendants. A fire vehicle rolled over the victim forward of the left wing, approximately 23 minutes after the accident.

The investigation to date has not identified any anomalies with the airplane prior to impact, although airplane system testing and performance evaluation is ongoing.

This investigative hearing will be structured in two main parts. The first three panels will examine issues significant to the conduct of the approach.

The first panel will explain characteristics and design concepts of the Boeing 777 and explore how automation and airplane state is displayed and used by pilots. The panel will examine the use of the autopilot flight director and autothrottle systems during a visual approach and will discuss the accident data as related to systems operation.

Panel 2 will focus on how pilots are trained on the automation systems operation and visual approach procedures. The panel will discuss Asiana Airlines' Boeing 777 training and Boeing support of the training. Specific training items regarding the use of automation systems will be examined as well as the training on and maintenance of manual flying skills such as visual approaches and stabilized approach concepts. Additionally, the panel will explore the supervision of transitioning pilots and the oversight of training programs by the Korea Office of Civil Aviation.

Panel 3 will be broader in scope and will examine the effects of increasing automation on the modern flight deck. The panel will discuss pilot workload and awareness and the implications for training programs and design and certification of highly automated flight decks.

The second part of the hearing will examine significant post-impact issues and will combine panels 4 and 5, focusing outside the airplane on emergency response training and tactics and use of equipment, and issues inside the airplane focusing on crashworthiness and occupant protection, especially seats and occupant restraint, interior materials, and evacuation system design and certification.

This concludes my opening presentation. I will be happy to answer any questions or proceed to the first hearing panel.

CHAIRMAN HERSMAN: Thank you, Mr. English.

I'll now call on the Hearing Officer to call and qualify the first witness panel. Mr. LeBaron.

MR. LeBARON: Thank you. Would the witnesses for Panel 1 please take your seats?

Chairman Hersman, Witness Panel 1 is composed of the following individuals, from my left, nearest the Board of Inquiry: Mr. Stephen Boyd from the Federal Aviation Administration, Capt. John Cashman from the Boeing Company (Retired), and Mr. Bob Myers from the Boeing Company.

The NTSB technical panel is composed of, starting on my right, Mr. Bill English, Mr. Jeong-kwen Park, Dr. William Bramble, the panel lead, Capt. Roger Cox and Mr. John DeLisi.

I now ask that the witnesses please stand to be sworn. Please raise your right hand.

(Witnesses sworn.)

MR. LeBARON: Thank you. You may be seated.

Chairman Hersman, these witnesses have been prequalified and their respective experience and qualifications appear in the docket as exhibits in Group 1.

I now turn the questioning over to Dr. William Bramble.

DR. BRAMBLE: Good morning, Chairman Hersman and Members of the Board.

We will begin with Panel 1, which will address B777 Flight Deck Design Concepts and Characteristics, and we will start the question with Capt. John Cashman, who was the 777 Program chief pilot in the mid 1990s.

Capt. Cashman, can you describe for us Boeing's flight deck design philosophy circa the mid 1990s when the 777 was initially certified?

CAPT. CASHMAN: Thank you, Dr. Bramble. The initial design actually started in about 1989. We used our Boeing flight deck philosophy that we had at the time, and we went out into the industry to our customers as well as the regulatory agencies and solicited inputs to find out if we needed to revise the design philosophy.

We worked with customer pilots, our own pilots, our own engineers and our own human factors people and discussed elements we needed to change or address with Airline Pilots Association, International Federation of Airline Pilots, and human factors experts from the academic world as well as NASA and FAA. The end result was we came up with a philosophy that was used not only for hardware design but the operation of the airplane. So it was an operation philosophy as well as a design philosophy.

Specifically, we came up with a number of elements, and I'll limit the ones I present today to the question about airspeed and energy and things of that type related to this incident.

The first one, the pilot is the final authority for the operation in the airplane. We try not to put in design elements that can override the pilot or second guess the pilot. We let him be the decider of what he wants in a given moment.

Secondly, both crew members are ultimately responsible for the safe conduct of the flight. They have assigned duties and they ensure the safety of the flight. We build the cockpit to operate in that manner.

We try to design for crew operations based on a pilot's past training and operational experience. That doesn't mean exactly the same airplane features, but basic operating philosophies of command authority, back to the very first flight lesson.

We accept the fact that pilots, as all humans, make errors. We try to make errors that can be corrected and noticed.

And lastly, at least for today, we apply automation as a tool to aid the pilot, not replace the pilot.

DR. BRAMBLE: Thank you, Capt. Cashman. Could we move on now to a description of the features of the 777 cockpit that were designed to support pilot airspeed awareness? And, Adam, if you could bring up Exhibit 14D, page 4?

Capt. Cashman, if you'd like, you can begin discussing it, and we'll use the visual aids as they become available.

CAPT. CASHMAN: We've got one. What's shown in this display is the mode control panel which is used to set up both manual and autoflight systems that the pilot will use. It establishes what the autothrottles will be doing, which control the thrust of the engine, and it controls either autopilot or flight director commands to the pilot.

If we could, I believe it would be the next slide to this one. Thank you.

As was mentioned in the opening, the primary flight displays are the primary source of air data and information to the pilot about speed and the energy state of the airplane. The upper center display displays engine operating parameters and also is where the messages system for the engine indicating and crew alerting system occurs.

One of the items that came out of our operating philosophy is we provide tactile as well as visual indicator cues to the crew as to the state of the airplane.

So the throttles, actually they're shown in the lower part of the center of the diagram. Always they move, and at full thrust, they will be full forward; at idle thrust, they will be full aft. And there's two of them and they're separate, one for each engine. The autothrottle can drive the position the position of the throttles as well as the crew. In all cases, they will move and be indicative of the operation of the autothrottle and the approximate amount of thrust that you're getting from the engines.

There are other items, the control wheel, which is not bounded there, but the control wheels are also backdriven, and so if you do a right turn, the wheel rolls to the right, the columns move forward and aft, and they provide information on the state of what the autoflight system is doing as well as what the other pilot is doing.

And lastly, the speed brake, which is to the left of the throttles, that moves either automatically or manually if it is armed. The system displays what the speed brakes are doing. Full forward is down. Full aft is full up.

So those are part of the operating philosophy as we give tactile, visual and, in some cases, aural feedback as to the state of what is going on.

DR. BRAMBLE: Can you step forward two slides, please, Adam? Can you just describe for us briefly how airspeed is displayed on the primary flight display?

CAPT. CASHMAN: Yes. On the left side, there's a moving tape which displays airspeed. Inside of that tape, the current airspeed in digits, they are rolling digits. So the rate of the roll and the rate of the speed tape movement are proportional to the actual speed change. One can get acceleration and deceleration cues based on the rate at which those parameters are moving.

Next to the little current airspeed window is a speed trend vector. The end of the green arrow, which is a variable, indicates where the speed will be at the current acceleration or deceleration in 10 seconds.

The pilot, from the mode control panel, can select the speed that he desires either with the autothrottle or as a reference mark, and it's called MCP select speed, at the top of the tape, and there's a magenta bug that runs along the right side of the airspeed tape.

From the flight management computer, which has a lot of navigation data and performance data, we can set the reference speed, which is a proportion of the stall speed and it's generally the minimum speed a pilot would be flying the approach at.

In the center of the blue portion is a parameter called pitch limit indicator. It indicates the attitude at which the stick shaker or stall warning will be going off. It is based on angle of attack. It is not just a number that's calculated. It actually is a variable and it gives a pilot how much margin to the stick shaker warning he has. As he approaches it and it touches, the stick shaker will go off.

The barber pole, down on the left, sort of a black -- it's hard to see -- and red, the barber pole, the top of the barber pole is also the speed at which the stick shaker goes off, and it is an angle of attack based parameter that will move up and down the amber band that is shown on the left part of the tape. So the amber band is fixed, and it's calculated number, the top of which is 1.3 g's where the stick shaker goes off. So if the pilot were to pull on the column, the stick shaker would go off at 1.3 g's, right when it got to the top of that amber band.

DR. BRAMBLE: Capt. Cashman, you mentioned also that the control column is backdriven even though this is a fly-by-wire airplane such that there is some force field to the pilot when he's trying to maintain a particular pitch. How does that force field system work when the airplane slows down if the pilot attempts to maintain the same pitch?

CAPT. CASHMAN: We have the option. When you build a fly-by-wire airplane, you actually have the capability to autotrim. In other words, you don't have to trim the airplane. We accounted for many nuisance trim requirements and did away with them, like thrust effects and flap changes, but we felt it was an important parameter to keep the basic speed stability. And that term means basically when you speed up, you have to push on the column; if you slow down, you have to pull, and we have to trim the airplane for a speed change.

When the pilot slows down to the top of the amber band, we inhibit the trim so the force that he starts to pull against becomes more and more, and as you pull all the way to stick shaker, the force gets to be considerable. Normal airplanes have about 3 pounds per 10 knots of force. If you go into the amber band and start pulling, it's on the order of 15 pounds. So a factor of 5, it would increase that force to make pilots aware that their speed is changing.

DR. BRAMBLE: Adam, can we have page 6, please?

Capt. Cashman, could you describe for us the major functional components of the 777 autoflight system? And by autoflight system, I mean the autopilot flight director and autothrottle systems.

CAPT. CASHMAN: I think Chart 9 might be a better start. Other way. I can basically start a little bit here.

We actually already went over in part the fact that the components of the autoflight system, when we say autoflight, we mean automatic pilot, autothrottles and flight director, which are the system commands to a pilot to do the part that the autopilot would do.

So we expect pilots to use a level of automation that is appropriate to the circumstance. If there's a confusion factor, we expect them to lessen that and go to a mode they know.

But what we're looking at here is the mode control panel display where a pilot would select speed, a speed reference, on the left side. The flight level change function that was mentioned in the introduction is on the left side; it is a single button push. And selected altitude, mode control panel altitude on the right. Now, the autopilot can use those as references as well as a flight director giving commands to the pilot.

The autothrottle function is actually at the far left, and it's an autothrottle button that you push to have the autothrottle work.

The annunciations of what those systems do are shown on the flight mode annunciator. The autothrottle mode on the far left, and that can work with no other displays there; in other words, no autopilot, no flight director. The autothrottle can be on in a speed mode; in other words, the thrust is controlling the speed of the airplane. The center mode is roll mode, and pitch mode on the far right.

Right above the sky/ground symbol is the autopilot status. It also shows flight director if it's only flight director and the different autoland functions. But it says if the autopilot is on, off or flight director.

You don't have to look at the mode control panel to find the status of what buttons are pushed or what equipment is working. You simply look at the flight mode annunciator.

DR. BRAMBLE: Capt. Cashman, can you describe for us how the pitch and thrust modes of the autoflight system interact to control airspeed and vertical speed pitch mode, versus flight level change pitch mode?

CAPT. CASHMAN: A pilot learns very early in his flight training, at least a power airplane pilot, that there's two ways to control speed. One is when thrust is fixed -- it could be full thrust or idle thrust -- speed is controlled by pitching the airplane. If he's flying level and he wants to adjust his speed, he changes the throttle setting.

The autopilot and flight director do the same thing. So there are times when pitch controls speed and times when thrust controls speed.

I think you wanted to focus on the flight level change particularly?

DR. BRAMBLE: Yes. How is the control of speed different for vertical speed versus flight level change?

CAPT. CASHMAN: In flight level change, which again was to go from one level to another level, either climbing or descending, it is the speed on pitch mode, or in some cases people call it speed on elevator mode. In other words, the elevator's pitching the airplane. So when you select flight level change, you are controlling the speed on the elevator.

Flight level change is a simple way to make a smooth altitude change. If you're asking it to climb, it will put in a partial amount of thrust for a small altitude change and a large amount of thrust for a large altitude change.

When you're descending, it does the same thing. If you're descending a short distance, it pulls back a small amount, lets the airplane descend in about 2 minutes or so to the next altitude. If you're descending, say, 10,000 feet, it'll pull the thrust back and go to idle. When it gets to idle, it will go into a hold mode and it will control speed entirely on pitch changes.

DR. BRAMBLE: And what causes the throttle to resume controlling speed in a normal FLCH descent and cruise?

CAPT. CASHMAN: The first step in deciding to use a flight level change function is to put in the altitude at which you want it to come out of the flight level change position. In other words, you put in the altitude you're going to, above or below, and then you select flight level change. When it reaches the target altitude, it will switch and capture the altitude, hold altitude and control speed with the throttle. So it's holding altitude with pitch now and speed with the throttles.

DR. BRAMBLE: Okay. And we are running a little bit short on time here, but if you could briefly walk us through the pitch and thrust mode transitions during the accident approach and how that affected control of speed, that would be appropriate now.

CAPT. CASHMAN: I don't have the chart, but it's probably just as easy. As was specified, the airplane started out in vertical speed, and we could reference the flight data recorder, but that may take more time than I can just do it. The vertical speed that was selected and started was changed to the flight level change mode part way in the descent for the approach. When that happened, they had already put in the missed approach altitude of 3,000 feet, which was above their present altitude. The airplane, because it now had a target altitude and flight level change was selected, the airplane started to climb.

Thank you. Let me pull up mine. Well, this one you can track where the changes are coming.

But when the flight level change mode was set, the pilot was telling the system that it wanted to climb in a flight level change mode. When he overrode that mode by disconnecting the autopilot, he was telling the system by our design that he wanted to fly manually and not have the autopilot fly. Also because he pulled the thrust back, it went into this hold mode and he reduced the thrust to idle.

So the airplane is now showing a climb, but he wants to descend, so he's flying away from the requested commands of the system, which would be normally controlling the speed either by the autopilot or by the flight director guiding him there. The key being if it's a flight director, he has to be following it.

So I can keep going here, but the autopilot was disconnected about 1500 feet. There were opportunities on the approach at the time the flight directors were cycled, or at least one was turned off. If they had both been turned off, the system would have gone to a vertical speed mode and the vertical speed mode would have caused the autothrottle to not be in hold but go to speed.

DR. BRAMBLE: Thank you, Capt. Cashman.

I'm going to turn some questioning now to Mr. Myers.

Mr. Myers, could you describe for us the 777 low airspeed alert feature?

MR. MYERS: Yes. Could we bring up slide 18, please, in this exhibit? Thank you.

The airspeed low alert, as its name implies, alerts the crew to a low airspeed condition, and the alert is one of many alerts that all are part of our crew alerting system, our centralized crew alerting system.

The centralized crew alerting system is on all of our wide-body airplanes and has been in service for over 30 years now. The system prioritizes alerts into three categories, as you can see in the table here. There's warning alerts, which require immediate crew awareness and immediate crew action. There are caution alerts, which require immediate crew awareness also but do not necessary require immediate crew action. And then there are advisory alerts, which require routine pilot awareness.

We achieve immediate awareness by stimulating two senses with the crew. So, for example, with a caution alert, there's an aural and a visual component to the attention-getting aspect of the alert. After that or along with that, the text message itself comes up on the center display between the two pilots in the central crew alerting area. And then also we display, as necessary, corollary information elsewhere in the flight deck to help the crew find the proper information they need to take any required action.

So if you would please, go to the next slide?

In the case of the airspeed low alert, that's a caution alert, and as I said, that means immediate crew awareness is required and potential immediate action. If the alert goes off, then the master caution lights will illuminate. There's one in front of each pilot. They're shown in the upper corners on this slide, and they're right on the glare shield in front of the pilots so that the pilots will see it whether their head is looking outside or whether they're looking inside at the displays.

Along with the alerts, the chime aural sounds which you heard earlier during Mr. English's presentation, and then also the airspeed low text appears on the center display. So the crew hears the alert, they see the alert, they glance at the display and they can then take the appropriate action.

If you would bring up the next slide, please?

Here's the primary flight display which shows the corollary information. Notice that the current airspeed box has turned amber. Obviously pilots know where the airspeed is displayed but we highlight it just to provide an additional cue, and we expect them to crosscheck it and take the appropriate action.

As you can see in this picture, the current airspeed is just a little bit more than halfway into the amber band region on the airspeed tape. The actual trigger for the low airspeed alert is about 30 percent of the way into the amber band, and that 30 percent number was picked intentionally as a place where it would be slow enough that we wouldn't have nuisance alerts but it would still provide adequate margin for the crew to take action before reaching the top of the barber pole, which is where the stick shaker or stall warning would activate.

DR. BRAMBLE: Was this feature a part of the 777's original design?

MR. MYERS: The airspeed low caution alert was not part of the original design. It was added later, a couple of years after initial cert.

DR. BRAMBLE: And why was it added to the airplane?

MR. MYERS: We had an event actually on a 747 in service that was up at cruise altitude. There was a system malfunction that caused the autothrottle to allow airspeed to decay, and the crew was engaged in other activities at cruise and they did not notice the speed decay until the stall warning occurred, and in the recovery they lost some altitude. We examined that event and felt that adding this caution alert and fixing the system problem that generated the specific incident on the 747, would be a good way to ensure that that never happened again.

But when we did the development of this low airspeed alert on all of our airplanes, we looked at all the operational conditions where we thought the alert might occur, and we picked the trigger points such that in all of these operational conditions it would provide adequate margin to stick shaker, yet not provide nuisance alerts.

DR. BRAMBLE: And in one or two minutes, if possible, could you describe the 777 autothrottle automatic engagement option?

MR. MYERS: The 777 has an automatic autothrottle activation option which engages or turns on the autopilot if it is off and the speed decays to a minimum speed. So it's the same as if the pilot would reach up and push the autothrottle button on the mode control panel. So if the autopilot is already on, it doesn't matter. I mean, it only is a feature for if the autothrottle is off and a minimum speed is reached.

DR. BRAMBLE: And did that activate in the accident scenario?

MR. MYERS: In the accident scenario the autothrottle was on, engaged in a mode, and so the activation feature is not relevant.

DR. BRAMBLE: I'm going to turn my questioning now to Mr. Boyd of the FAA.

Do you have knowledge of the FAA's approach to evaluating and certifying the 777 flight deck in the mid 1990s?

MR. BOYD: Yes.

DR. BRAMBLE: Could you describe the FAA's approach?

MR. BOYD: Well, evaluating the flight deck is a process that takes place over the entire certification program as part of the overall airplane certification. It starts when we become aware of the new airplane program, when the applicant, such as Boeing, applies for its type certificate. Our specialists and pilots become involved early, become briefed on the designs, and we establish the certification basis for the airplane, which would be the rules that are in effect, will be in effect for that airplane, the regulations.

We then begin a program of compliance planning with the applicant, where we work together to determine what means of compliance will be used to show that the design is compliant with all the regulations.

There's a design phase that continues, and then we reengage as the applicant begins producing analysis, design and test data that is used to support the findings of compliance. Those are evaluated by a number of FAA people across a wide variety of specialties. And after the design comes together, the airplane's built, and at the tail end, then, flight testing begins and flight testing then is the final phase of the critical evaluations of the flight deck.

And at that point, we have already typically seen a great deal of data associated with things like system safety effects and system reliability, all the things that are part of the general regulations that apply to the airplane and also apply to flight deck systems.

And then the test program, the flight test program brings all of that together and we put our pilots in the airplane with the applicant's pilots and evaluate all aspects of the design, including handling characteristics, performance, and the human factors aspects of the flight deck.

DR. BRAMBLE: Can you describe a certification issue involving the autoflight system that was identified by an FAA test pilot during the 787 type certification program? And let me preface that by saying that it's our understanding that the 787 autoflight system has similar design logic to the 777.

MR. BOYD: I assume you're referring to a specific issue raised during the 787 program by our test pilot related to the wake-up function of the autothrottle, where there was -- we were conducting a flight test and there was a flight level change initiated and the flight level change was interrupted by another event. In this case, it was a traffic avoidance event, and as a result of the logic of the airplane, the autothrottles went into hold mode. Our pilot, as would normally be expected, was monitoring airspeed and noticed airspeed was decaying, and then as part of this test pilot functions, allowed the airspeed to decay further to see what would happen.

And our test pilot was expecting at that time, he believed that the autothrottle would wake up, not realizing that the autothrottle, since it was on -- as Mr. Myers explained, if the autothrottle was on, the autothrottle would not wake up; it was already awake. And so he allowed speed to decay and at a safe point, he put throttles back in, brought the thrust back up and continued the flight.

He raised that as what is called a response item. Basically it is just a way for the FAA to document a potential concern and to get a response from the applicant, in this case, Boeing, a response to the question about why it works that way and to determine if it is acceptable.

In the process of doing that evaluation, working with

Boeing on this one, our FAA pilot determined that the fact that the autothrottle did not wake up was not a safety issue nor was it a regulatory noncompliance. Given those two critical factors, at that point, he believed it was still an area where there could be improvement and he worked with Boeing to include additional information in the flight manual to explain that the autothrottle on the 787 would not wake up from an autothrottle hold.

DR. BRAMBLE: Thank you, Mr. Boyd.

That concludes my questioning, Mr. LeBaron.

MR. LeBARON: Thank you very much.

Capt. Cox, we'll turn it over to you.

CAPT. COX: Good morning. Would you bring up Exhibit 14D, page 16, Adam?

MR. LeBARON: And, Capt. Cox, just to inform you, the timer there is our total time left for this panel, and we have one more question after you're done.

CAPT. COX: Okay. Capt. Cashman, how long has flight level change and hold been a feature of Boeing airplanes?

CAPT. CASHMAN: An almost identical control law that controls flight level change goes back to the early 1980s, on the 757, 76 airplane and was used in the 47-400, 777 and 87.

CAPT. COX: Our accident pilots flew respectively the 747-400 and the 767. Can you tell me what change in the autothrottle activation or the hold mode of flight level change mode took place on the 777 versus those earlier airplanes?

CAPT. CASHMAN: To my knowledge, certainly from the aspect of the hold, there were no differences. They're identical.

CAPT. COX: Why does Boeing think an autothrottle hold mode is necessary?

CAPT. CASHMAN: Hold is a normal operational feature that pilots use or can use to vary the rate of climb or descent from one level to another. They can manually set the thrust to vary the rate that the system is using. They may have some passing traffic; they want to cut the rate. They can do that without disconnecting the autothrottle. In prior airplanes, we would have had to make a disconnect.

It's also used and a number of airplanes have heavy icing procedures that establish minimum engine rotor speeds in heavy icing to get engine and wing anti-ice. And we set a thrust while climbing or descending and it will stay in that position until reaching the selected mode control panel altitude.

CAPT. COX: Did Boeing consider putting on an automatic autothrottle activation at a minimum speed regardless of the status of the modes?

CAPT. CASHMAN: We certainly always look at possibilities. The main problem with that is, it goes back to that original philosophy, is not changing modes in an autopilot that the pilot doesn't command. What would happen if you just activated the throttle is you would have two controllers of one parameter. The autopilot would be controlling speed by pitching, and the autothrottle would be controlling speed by changing thrust. It doesn't work very well. So you have to make a mode change, put the autopilot in a different control mode and/or the thrust. So it's difficult to do, and it was violating one of our fundamental design concepts.

CAPT. COX: Okay. What is displayed on the FMA when your flight director is turned off?

CAPT. CASHMAN: Without going to any pictures, it's pretty simple. When the flight director's turned off -- on both sides are we talking or one side?

CAPT. COX: Just one side.

CAPT. CASHMAN: So if the flight director is off on one side, the command bars go away. If the other side is on, the flight mode annunciator will still show the modes that are being displayed on the other side, and the throttle which would be in independent of the flight director will show whatever mode it's in.

CAPT. COX: So then in case of both flight directors being turned off, what is displayed on the FMA?

CAPT. CASHMAN: The FMA would be blank for the pitch and roll modes. If the autothrottle was engaged, it would be in a speed mode. It would say SPD, which is the only mode in which it ever controls speed is when it says speed.

CAPT. COX: Very well. So in the case of our accident crew, we apparently had the flying pilot with his flight director off and the non-flying pilot with his flight director on, leading us to believe that there would have been a partial display for the pilot flying.

CAPT. CASHMAN: There would have been no pitch command bars for flight director on the off side.

CAPT. COX: Okay. Great.

Thank you, Madam Chairman.

MR. LeBARON: And we have time for one more question. Mr. Park, we'll turn it over to you, and I'll be listening and when the translator's ready for your next statement, I'll give you the signal. So go ahead.

MR. PARK: According to -- can you please put the Docket 14D, page 18, please?

I have a question to Boeing's Robert Myers, Chief Engineering. You just explained that the caution warning alerting is issued when immediate crew action is required and the caution alerting is a lower level alerting than warning alerting and it doesn't require immediate action, but the pilot should be aware of the situation, according to your statement.

But in the sequence of this accident, there is something I don't understand. In the cockpit of the Asiana 214, 11 seconds before the impact, the airspeed was below the minimum maneuvering speed so there were four beeping sounds was first initiated. And 7 seconds later, there's still warning alerting, which is a stick shaker activation is issued, and 2 seconds later, the airspeed increased, and another 2 seconds later, the aircraft struck the seawall.

But actually, the pilot, before the stick shaker activated -- I mean, 3 seconds before the stick shaker activated is under the caution alerting situation, the pilot pushed the throttle to its maximum and 5 seconds later, the aircraft speed increased. So before the warning alert is issued, the aircrew actually increased its thrust to its maximum but the aircraft actually came to strike the ground. Can you please explain in terms of low speed alerting about this?

MR. MYERS: Yes, let me explain. As I said, the airspeed low alert is a caution which means immediate crew awareness and then potential crew action. So it is up to the pilot to determine whether the action is immediate or whether it can be delayed.

The reason it's a caution is because, if you recall, I said that the original scenario for which we designed the alert was a cruise condition, and so in that case, often there is much more time before the pilot must take an action. In the case of being on final approach, as in the accident scenario, we built in still some reaction time for the crews, and the reaction time in this case falls well within the range that we designed the alert for.

And also, we need to remember that the airplane was well below airspeed, but when you're in the amber band, the airplane is still flying and it still can be maneuvered, just with less margin than at the top of the amber band. So there was maneuver capability in the airplane and the airplane is still flyable at that speed. The issue here was that there was a glide path correction required and airspeed correction required, and this alert was for the airspeed portion.

MR. LeBARON: Chairman Hersman, that's all the tech panel has for now.

CHAIRMAN HERSMAN: Thank you very much. We how have a break until 10:10. We will reconvene for party questions at 10:10.

(Off the record at 9:53 a.m.)

(On the record at 10:10 a.m.)

CHAIRMAN HERSMAN: Welcome back. Are any of the parties or panelists or tech panel having any problems with their headsets with the translation?

Okay. We will now proceed to the questions from each of the parties. We will go in order. Each party will have a 5-minute round. You may pass if you want. Just so you have some situational awareness about your time, you will see lights up on the table where the witnesses are: red, yellow and green. Green you have 5 minutes; it will turn yellow when you have 1 minute left, and red when your time is up. Just to help you if you're not able to keep track of the time.

We'll now begin with questions from Asiana Airlines.

CAPT. KIM: Thank you, Madam Chairman. I have three questions for Capt. Cashman or Mr. Myers.

First, initially I would like to refer to Exhibit 14I, at page 6, please. 14I, India.

In a report, 22 May 2011, EASA, European Aviation Safety Agency, noted that in certain automation modes, the autothrottle wake-up function of Boeing 787 was not operative and therefore does not protect the aircraft. EASA noted that inconsistency in automation behavior has been in the past a strong contributor to aviation accidents and concluded that Boeing would enhance the safety of the aircraft by avoiding exceptions in the autothrottle wake-up mode.

Why didn't Boeing devise its automation design to address this recommendation?

MR. MYERS: This EASA recommendation came up during the 787 certification in a similar manner as the FAA response item that we discussed earlier. This came out as a recommendation, which means that Boeing is not required to respond and it is not a certification issue.

I should reiterate that both the FAA and the EASA evaluated the design of the FLCH hold mode and the autothrottle activation features. They found the features to be safe. They found that they met certification requirements and both agencies certified the operation of the airplane.

When we demonstrated these features, and when we discussed with the FAA and EASA our reasons for the design, they agreed with them and the response was that we should add some information into our manuals. In the 787, it's added to the Airplane Flight Manual. In the case of the 777, there was already equivalent language in the Flight Crew Ops Manual, so we didn't need to make any changes there.

CAPT. KIM: Next question. I would like to refer to Exhibit 2B at page 117, please.

CAPT. CASHMAN: Could you repeat the page number, please?

CAPT. KIM: Exhibit 2B, Bravo, at page 117, 1-1-7, please. Thank you.

FAA lead test pilot, Capt. Eugene Arnold, stated that he was caught by surprise by a feature of the autopilot design philosophy, namely, that in certain autopilot modes the autothrottle will not wake up even during large deviations from target speed and does not support stall protection. He identified this as a safety issue.

Given that Capt. Arnold was a highly experienced FAA test pilot, does the fact that Boeing's automation logic surprised him indicate a problem with the automation design?

CAPT. CASHMAN: I think the issue really was that there was a misunderstanding when the autothrottle would wake up and when it was controlling speed, and Capt. Arnold did not select a new altitude or hit altitude hold, so it did not revert to speed mode on the autothrottle. He was not following the commands, but he was operating the system, and he was monitoring the speed when he leveled off, which is how he caught the condition. In the end, when he understood that this design goes back to the 757/67 and 210 million flight hours, I think he felt it was not as critical an issue, but we did take his advice and put the words in the manual.

CAPT. KIM: Thank you. Final question, when FAA mandated improvements in the 787 manual on flight level change, did Boeing consider implementing changes in the manuals of other planes with the same system and what about in the FCOMs of the 787 or the other airplanes?

MR. MYERS: The words that were added to the Airplane Flight Manual for the 787, the equivalent words are already in the 777 Flight Crew Operating Manual, the FCOM, and they have been for at least 15 years. That's as far back as our history could go. So we didn't need to add additional words to the manual. It's already there.

CAPT. KIM: Thank you.

CHAIRMAN HERSMAN: Asiana Pilots Union.

CAPT. MIN: Yes, Madam Chairman. Capt. Cashman, you talked about autothrottle wake-up. Isn't really an issue autothrottle envelope protection?

CAPT. CASHMAN: The envelope protection of the auto-engage or wake-up function is an element of the stall protection, but it is not the stall protection system. In other words, it's related to operation when the autothrottle is turned off or it has been disengaged inadvertently or a failure dropped it off, that it will engage itself. It's not a function that if the autothrottle is already in another mode, it will change the mode and do something to control speed. It was really there to come alive and engage itself when it had been selected off.

CAPT. MIN: Capt. Cashman, I'm looking at FCOM, 4 page, 2.9. Why autothrust won't support stall protection in flight level change?

CAPT. CASHMAN: I'm sorry.

CAPT. KIM: FCOM, 4 page, 2.9.

CAPT. CASHMAN: Is it 20.9?

CAPT. KIM: Yes.

CAPT. CASHMAN: Okay. I have page 4, 20.9. And I'm not clear on the question, I'm afraid.

CAPT. KIM: Why autothrottle won't support stall protection in the flight level change?

CAPT. CASHMAN: That's right, and what we demonstrated in our training scenario to expose crews to the feature, and again, it's demonstrated by turning the autothrottle off when it is engaged and it will come alive. And that's really what it says and that's what it does. It's in the Flight Crew Training Manual as well. Perhaps I'm misunderstanding the question.

CHAIRMAN HERSMAN: Capt. Min, would you like to rephrase the question?

CAPT. MIN: Okay. Last question, then, I will ask again.

Mr. Myers, has there always been a note in the Boeing FCOM regarding no autothrottle wake-up in flight level change mode?

MR. MYERS: In the 777, there has always been the note. It was originally in Chapter 9, which is the stall protection chapter, but it was relatively recently moved to Chapter 4 when we did an audit of our manuals and tried to make them more consistent across the models, and also we wanted to make sure that all the autothrottle information was in the autothrottle chapter. So we moved it from Chapter 9 to Chapter 4, but it has always been in the manual.

CAPT. MIN: Capt. Cashman, how reliable is the autothrottle to maintain the select speed?

CAPT. CASHMAN: I'm not sure, in terms of how to express reliability. It's a reliable system, but it is a fairly simple system and it can disengage, which is why we have crew members with their hands on the throttle in critical states, critical operations. But I couldn't give you a probability number as to what the reliability terms are. I don't have that information. We might be able to get it, but to be honest, I don't know of a chronic service problem with autothrottle disconnects.

CAPT. MIN: Capt. Cashman, I ask again the question, why no autothrottle speed protection in flight level change mode?

CAPT. CASHMAN: The autothrottle protection feature or wake-up feature is only when the autothrottle is turned off. In a flight level change mode, the speed is being controlled by pitching the airplane, not by moving the throttle.

CAPT. MIN: Okay. I have no more questions. Thank you, Madam Chairman.

CHAIRMAN HERSMAN: Thank you.

Air Cruisers.

MR. O'DONNELL: Madam Chairman, we have no questions. Thank you.

CHAIRMAN HERSMAN: Thank you.

Boeing.

MS. BERNSON: Thank you, Madam Chairman.

Capt. Cashman, can you please describe the FAA demonstration of flight level change mode during 777 certification?

CAPT. CASHMAN: Yes. There was a specific test done with a FAA certification pilot and engineer on the 777 to demonstrate in flight level change hold mode that there is no wake- up or auto-engagement feature, and that was demonstrated. It did not wake up, and that was the correct response and it was certified that way on the original 777.

MS. BERNSON: Great. Thank you.

Boeing has no further questions.

CHAIRMAN HERSMAN: Thank you.

City and County of San Francisco.

MR. McCOY: Madam Chairman, we have no questions.

CHAIRMAN HERSMAN: FAA.

MR. DRAKE: Madam Chairman, FAA has no questions.

CHAIRMAN HERSMAN: Okay. We'll move to the Board Members. Member Sumwalt.

MEMBER SUMWALT: Mr. Myers, good morning. You stated that -- I believe you stated earlier in response to a question from Mr. Park, when he asked about the levels of alerting there, the warning and the caution, and as I recall, you indicated that the caution, when you put the caution in there for the low speed alerting, you did it for the cruise phase of flight. Did I understand you correctly?

MR. MYERS: That was the original impetus for designing the alert. It was designed ultimately to be used throughout the entire flight regime.

MEMBER SUMWALT: Okay. Because I was looking at 14 CFR 1322, and it doesn't just say that the levels of alerting would apply just to the cruise segment. So you're saying that -- was there consideration to adding a -- for example, I flew an Airbus, an A320, and it had an aural alert that said "speed, speed, speed." Was there any consideration to giving a more salient alert than just simply a master caution and an EICAS warning, EICAS alerting?

MR. MYERS: Yes, we certainly looked at as we designed the alert. Remember that our low speed protection is actually an entire hierarchy of indications that we provide to the crew. We provide guidance and control information, if the crews choose to select it on. We provide performance indication in terms of current airspeed and vertical speed, et cetera, and we also then provide a whole host of supporting cues, like the amber band and the barber pole and the pitch limit indicator. And then we also provide tactile feel back to the crew so that they can tactilely tell from both the position of the column and from the trim situation that they're getting into a slow speed condition. And we also have out-the-window cues, even if their heads are out, that they can -- like such as deck angle, that their airspeed is getting slow.

So the airspeed low alert is just one element of that entire progression of cues, and the ultimate cue of stall is the stall warning. We do have a stall warning. It's the stick shaker. It's both audible and they feel it in their hands on both sides. So we do have a full progression of stall warning and low speed protection, and this airspeed alert is just one element.

MEMBER SUMWALT: I'd like to call Exhibit 14D, please, page 1. And, Mr. Myers, the fifth bullet point down it says that the flight deck philosophy is to design systems to be error tolerant. What is meant by error tolerant?

MR. MYERS: When we design systems to be error tolerant, we consider two basic things. First, we try to design the system such that we minimize systematic error and the system itself doesn't lead to errors on the part of the crew. But then we also design the system to mitigate random human error, because errors will always occur. So that is why we build in this whole progression of protections that start off relatively subtle and are going to get more and more salient until the ultimate warning.

MEMBER SUMWALT: So given that, the situation where when the flight level change and the autothrottle is in hold, do you consider that to be an error-tolerant design?

MR. MYERS: I think I should reiterate briefly what Capt. Cashman was talking about. We looked at this design and we were faced with a design choice. If we did a wake-up or some sort of mode transition of the autothrottle and hold mode for a low speed condition, say, we would have had to transition the mode without the pilots authorizing that change. It would have been an uncommanded mode change, and then we would have had most likely two systems controlling speed, both the autothrottle and the autopilot, which would mean we would also have a mode change in the autopilot system so that we could rectify that situation.

So in that case, we would end up with two mode changes and a thrust increase, and if the slow speed condition came about, say, because of an engine problem, we might also be pushing thrust up into an asymmetric thrust condition. So we would have potentially two mode changes uncommanded by the pilot; we would have a thrust increase, possibly an asymmetric thrust increase; and we'd be violating our philosophy of the pilot being the final authority.

So we looked at the two situations. We thought the less confusing of the two was, in fact, the design we chose.

MEMBER SUMWALT: Thank you very much.

CHAIRMAN HERSMAN: Member Weener.

MEMBER WEENER: Thank you.

A question for Mr. Cashman. When a flight deck development as big as the 777 comes along, who do you go to, to get information and review? Who in the industry do you have take a look at the flight deck, the design?

CAPT. CASHMAN: Well, when the program launched, we hired quite a few additional human factors people than we had previously had. But we went out, we brought in teams for several audits and design commissions: Airline Pilots Association, International Federation of Airline Pilots, human factors people from NASA, FAA, a number of universities, both foreign and domestic. It was a large group of people. We also brought in, with our customer airlines, some line pilots that actually sat in our design meetings and gave us input on various features and problems.

MEMBER WEENER: And what role do the kickoff customers have in terms of reviewing the design?

CAPT. CASHMAN: Well, some of our earlier customers, we had both engineering and pilot teams at the company sitting through most of our design reviews. There were only three or so airlines at once, that I recall, that were in that role, but they provided a lot of input. We brought in teams from their airlines to review both the training syllabus as well as different technical functions as we moved the airplane along.

MEMBER WEENER: And who were the kickoff customers for the 777?

CAPT. CASHMAN: United was the kickoff customer on the original 777.

MEMBER WEENER: And who else followed them, closely behind that? Who would have been involved in those reviews?

CAPT. CASHMAN: Oh, British Airways was involved, ANA. There were eight of them, and I'm trying to remember. JAL, ANA, Cathay Pacific.

MEMBER WEENER: But it wasn't simply U.S./Western airlines; it was worldwide?

CAPT. CASHMAN: Yes, absolutely. Absolutely.

MEMBER WEENER: Now you sell airplanes around the world operated by people from all kinds of different cultures. How do you handle the cultural differences that are inherent in different parts of the world?

MR. MYERS: We try to engage, as Capt. Cashman said, airline pilots and folks from all over the world when we design the systems. We try to accommodate English as a second language.

We try to accommodate cultural differences as we make the design. Now we're a bit fortunate in that English is the language of aviation, but we do understand that English is a second language for many.

So, for example, on the 777, we went through and audited every single one of our alert messages and we reorganized them to make them as short and as clear as possible. We made sure that we didn't abbreviate words differently on the text message, say, than we did on the checklist, so that pilots could make character matching. And so we did a number of things like that through the design process to make it as simple as we could.

MEMBER WEENER: Are there any variations in the flight deck depending on which part of the world an airplane gets delivered to?

MR. MYERS: There are a few. We have, say, units, Fahrenheit versus Centigrade for temperature, and kilograms versus pounds for weight. But, in general, no, we have a very consistent design across all of the airplanes because they tend to move around.

MEMBER WEENER: So the design philosophy doesn't change depending on which part of the world?

CAPT. CASHMAN: No, it doesn't, but there's more regional variation probably to navigation requirements and what equipment goes on the airplane than the architecture. At one time we built airplanes and actually made cockpits that had switches go one way for part of the world and another way for the other, and some in foreign languages, but that's pretty much standardized now.

MEMBER WEENER: Thank you.

CHAIRMAN HERSMAN: Member Rosekind.

MEMBER ROSEKIND: This is for either Capt. Cashman or Mr. Myers. There's the design philosophy, then there's execution. Can you please talk about any formal process you have to identify the discrepancies between how the design was intended and how it actually ended up being executed? What formal processes do you have to identify those discrepancies and then address any changes that need to be made?

MR. MYERS: So when we go through the development process, we have a formal aircraft development process, and at numerous stages in the development of the airplane we go through design reviews. And in those design reviews, we bring in a wide variety of people, including the FAA and other regulators, pilots from all over the world, and a lot of different people within the company. In addition to those design reviews, we always have an engineering simulator or two, and we go through a long series of structured tests to evaluate just that. We look for areas of negative transfer, areas of confusion, areas where there may be systematic error, and we make corrections as we can.

Once the airplane is in service, we have a very formal safety process where any incident that comes up is reviewed as a potential safety item. It's tracked all the way to completion if it's determined that it is.

MEMBER ROSEKIND: And let me get you focused a little bit more. So I'm trying to get -- you know, when you talk about error tolerant, it's human centered, where's the process that actually makes sure that what ends up in the cockpit lines up with that philosophy? And I appreciate the venues you just talked about. Now I'm wondering what's the formal process within those venues that somebody's actually saying, well, the way this alert went on doesn't reflect our intended philosophy of, you know, the pilot's awareness of this? I mean, where does that formal evaluation take place?

MR. MYERS: So we have a series of requirements that we develop. The top level requirements are these philosophies that we've been showing you and others, and then we have a couple of tiers of requirements below that, and they're all annotated as parent-child, and as we go through the reviews, we look at these requirements and we look at the next lower level of requirements.

Like, for instance, the quiet, dark concept that we use in the design of the airplane is actually a lower level requirement than the top level of philosophies you saw on the display today. And then below that, we start getting into specific design requirements for the airplane and below that are the very specific design requirements that we provide to our suppliers of our avionics equipment or the flight controls equipment, et cetera. And all of those requirements are tied to the higher levels to make sure that we've got good parent-child relationships with all of those requirements. So that enables that kind of discussion that you're talking about.

MEMBER ROSEKIND: And then the process change. So somebody identifies during that review that, you know, here's what we intended from a design standpoint but here's what it's doing in the cockpit. What's the change process to make sure it gets addressed?

MR. MYERS: So the change process is that someone identifies a specific requirement issue. Then we will formally evaluate the requirement and make a change, and if there are changes made to a specific lower level requirement, then we need to necessarily review the parent relationships and see if that means that there's a change there, and we need to alter that or we need to expand it because the world has changed or whatever. And so that would lead then to changing the upper level requirements.

But we've also had it where the opposite has occurred. Someone has an issue and we review the higher level requirements and say, no, those higher level requirements are valid; we need to do something else for the lower level requirement, and go back and review it again.

MEMBER ROSEKIND: Okay. Thank you.

CHAIRMAN HERSMAN: Vice Chairman.

VICE CHAIRMAN HART: Thank you.

Capt. Cashman, if I heard you correctly, I think heard you refer to using the mode control panel for various aspects of manual flight. Did I hear that correctly?

CAPT. CASHMAN: Yes, you did.

VICE CHAIRMAN HART: Could you give me an example of how you might use the mode control panel for a manual flight? What would it do for me?

CAPT. CASHMAN: The most basic would be you're hand flying the airplane and you want a heading marker. You would have put the heading on the mode control panel or the altitude alerting system would be set with the mode control panel altitude select, so if you deviated from an altitude, it would alert you.

VICE CHAIRMAN HART: Could I command a vertical speed and fly it manually and then the flight director bars would alert me to that?

CAPT. CASHMAN: If you had the flight director engaged, yes.

VICE CHAIRMAN HART: And let me ask you about the flight level change mode. Does the speed remain constant during flight level change?

CAPT. CASHMAN: If you're following the guidance, yes.

VICE CHAIRMAN HART: And how does the system determine what rate of climb or descent to use? Is that based on the distance that you're climbing or descending?

CAPT. CASHMAN: That's correct. If it's a short distance, it will attempt to reach that new altitude in 2 minutes. It adjusts the power to give an approximate rate at that level. So, for instance, if you're climbing 1,000 feet, you don't put in full thrust; you just put in a small amount of power to climb. It's much more economical. If you're climbing 10,000 feet, then it would go full thrust.

VICE CHAIRMAN HART: Okay. Thank you.

Now a couple of questions about the autothrottle. If I understand correctly, if I disengage the autopilot by doing something, manually overriding the autopilot, then I get a chime. Is that correct?

CAPT. CASHMAN: Yes.

VICE CHAIRMAN HART: Is there any kind of analogous chime if I do something to override the autothrottle?

CAPT. CASHMAN: Of you disconnect the autothrottle, then you will get an alert on the EICAS display and a chime.

VICE CHAIRMAN HART: Okay. If I manually override the autothrottle, what indication will I get?

CAPT. CASHMAN: No, you don't because if you're overriding, you're physically giving it a command.

VICE CHAIRMAN HART: I see.

CAPT. CASHMAN: It's considered a normal thing to do so we don't alert that.

VICE CHAIRMAN HART: Thank you.

Okay. A couple of questions for Mr. Myers. Could I get the Boeing slide that talks about airspeed low caution level alert? Yes, that one.

Mr. Myers, you mentioned that some of these features, it wasn't clear to me which, came as a result of a low speed event in a 74 that caused you to expand the response to that into some of the other airplanes in the fleet. Did I understand that correctly?

MR. MYERS: Yes, you did. This particular alert came about as 747 incident.

VICE CHAIRMAN HART: So which aspects of this alert are you talking about? I'm looking at several aspects. I'm looking at the caution warning light. I'm looking at the aural symbol, the yellow box around the airspeed, and then the airspeed low indication in the center screen. Which of those aspects was already there and which resulted from the 74 incident?

MR. MYERS: The crew alerting system was there from the very beginning. It was developed on the 57, 67. It's on all of our wide-body airplanes. So the whole concept of the master caution light, the master caution lights are in front of the pilots, the master caution aural, all of that system was in place. So all we did in this particular event was add an additional caution message to the existing system. So before, there were, you know, 70-some cautions. Now there's 70-some plus 1 after this.

VICE CHAIRMAN HART: So the yellow box around the airspeed was already present?

MR. MYERS: No, that was added also. That corollary information along with that alert was added as well.

VICE CHAIRMAN HART: Okay. So how widespread in the Boeing fleet are those several areas of airspeed low caution?

MR. MYERS: The airspeed low caution is on all of our EICAS airplanes.

VICE CHAIRMAN HART: With all of these aspects, the master caution light, the aural, the airspeed low and the box around the airspeed?

MR. MYERS: Yes.

VICE CHAIRMAN HART: Do you have any sense, if you know, of how common that is in large transport airplanes, those features for airspeed low?

MR. MYERS: I'm not familiar with the specific designs for all of the other airplanes.

VICE CHAIRMAN HART: If you know, do you have any sense of the airspeed low warning in an Airbus, if that's a fair question to you, if you know?

MR. MYERS: I know they have an alert, but I don't know the details of how it actually works.

VICE CHAIRMAN HART: Okay. Thank you.

CHAIRMAN HERSMAN: Just to wrap up, and since we still have that slide up, if we could pull that slide back up? I wasn't quite clear on what existed before versus what changed after the

74 event. When did the 74 event take place?

MR. MYERS: The 74 event took place right about the time the 777 went into service. I forget the exact date. I think it was sometime in '95, which is the year the 777 went into service, and then it was I think '96 or so, where we actually implemented the new alert on the 777.

CHAIRMAN HERSMAN: And specifically what's new?

MR. MYERS: The only thing that's new of the whole hierarchy of low speed alerting, from display indications through the stall warning, is the single caution message that comes up and the amber box around the current speed that correlates with it. That's the new part. The caution system and all the other stall warning cues were part of the original 777 design.

CHAIRMAN HERSMAN: Okay. I'd like to ask a basic question of Mr. Boyd. What's the purpose of automation?

MR. BOYD: Are you asking from a regulatory perspective?

CHAIRMAN HERSMAN: I'm asking for a one sentence answer of the basic of what's the purpose of automation.

MR. BOYD: Madam Chairman, it's very difficult to answer because there is such a wide range of what automation means. It's not a clearly defined term. It could be anything from something very complex like an autoflight system to the pressurization system controlling the outflow valve, rather than a manual control, all the way to some other very minor function. It's such a broad term, it's hard to say what the purpose is, and I guess I would have to say it depends on what you're automating.

CHAIRMAN HERSMAN: Okay. So what's the purpose of autothrottles? Is it to reduce workload? Is it to increase safety? I mean, I'm just looking for a really big picture understanding of why you would implement that rather than manually fly all the time, be responsible for throttles all the time?

MR. BOYD: Well, I would say that's fundamentally a question for the designers to answer. It's not a regulatory mandate.

CHAIRMAN HERSMAN: So when you look at the certification of a system like that, what are you looking for?

MR. BOYD: Well, the two major questions that we look for in any certification issue is, does it comply with the regulations and is it safe?

CHAIRMAN HERSMAN: Can something comply with the regulations but not be safe?

MR. BOYD: Absolutely, absolutely. Regulations do not cover everything. So we can find that a given design, while not -- there may be some aspect of it that is not covered by the regulations that we deem to be unsafe, and then under the aircraft certification rules of Part 21, we can require a change to the airplane to address an unsafe condition.

CHAIRMAN HERSMAN: Okay. For Boeing, as you all are designing aircraft, would you say that the aircraft that are being delivered now versus the aircraft that have been delivered in the past are being equipped with more automation or less?

CAPT. CASHMAN: Compared to at least the last 25, 30 years, they're very similar. There have been increases across the fleet particularly in the navigation and the modes that affect economy, that our customers want, the world wants, to be able to improve the efficiency of aircraft. But for the most part, the autoflight modes that do that are very similar back to the early '80 models of airplanes.

CHAIRMAN HERSMAN: Okay. You made a statement earlier that the autothrottle system is a reliable system, you said, but it's simple. What did you mean that it's simple?

CAPT. CASHMAN: It's not an autoland system. For instance, an autoland pilot for landing, there's generally three of them voting and deciding. An autothrottle is more or less a single thread system that if anything in that system hiccups, it can drop off.

CHAIRMAN HERSMAN: Okay. What's the purpose of stick shaker for the Boeing designers? When would you expect it to alert? Is it going to alert in time for the aircraft for the pilots to escape from the situation? When does stick shaker alert?

CAPT. CASHMAN: It alerts to the potential of the airplane stalling.

CHAIRMAN HERSMAN: So it doesn't necessarily account for the time that they might need to get out of it?

CAPT. CASHMAN: I can't remember the exact regulations, but we do look at a variety of entry rates. It depends on how many knots per second you're losing speed and how fast the pilot reacts, but in most cases it is enough to prevent a full stall.

CHAIRMAN HERSMAN: And the low speed alert, is that provided in enough time to actually be able to obtain the needed speed?

CAPT. CASHMAN: To prevent a stall?

CHAIRMAN HERSMAN: Yes.

CAPT. CASHMAN: Yes.

CHAIRMAN HERSMAN: Even accounting for spool-up time for engines?

CAPT. CASHMAN: We looked at a variety of conditions, but that again is still dependent on -- there are corner conditions where you can eventually end up where it will not. But that whole characteristic of what the airplane is doing prior to the stall and the other cues, we designed to prevent you from getting there. But the alert itself will, in almost all cases, be enough to prevent a full stall. Not if you're going straight up, for instance, but it is in a normal flight of a jet transport.

CHAIRMAN HERSMAN: Are there any additional questions from the Board Members? Member Sumwalt.

MEMBER SUMWALT: Thank you.

Mr. Myers, I told you I flew the Airbus and it had an aural warning alerting that said "speed, speed, speed." In response to the 737 accident, Turkish Airlines accident in Amsterdam, did Boeing make a modification to the 737 similar to what I'm describing that's on the Airbus?

MR. MYERS: Yes, we did. After the Turkish accident, we did add a "speed, speed, speed" aural to the 737. The 737 does not have the EICAS system that the other Boeing airplanes have, so the alerting system is different and the philosophy around the alerts is different. So in the case of the 737, to do an equivalent alert, we had to use a different design. Because we don't have unique aurals for cautions and warnings on that airplane, we need to get immediate awareness from the crew in a different manner. And because we don't have centralized messages, we need to highlight the area that the crew needs to attend to in a different manner. So that led to a different design for the 737 than for our EICAS airplanes.

MEMBER SUMWALT: Thank you.

CHAIRMAN HERSMAN: Member Weener.

CAPT. CASHMAN: Madam Chairman?

CHAIRMAN HERSMAN: Yes, Capt. Cashman.

CAPT. CASHMAN: If I could add to that one question you asked about the stick shaker? To put some of this in perspective, when we are in a wind sheer event with very high wind gradients and very turbulent conditions, we are having the pilots fly the airplane at the stick shaker, and there are very high movements, pitching up, pitching down, and it's adequate to do that in very severe conditions. That kind of bounds whether the alert is timely enough to prevent a stall.

CHAIRMAN HERSMAN: But the conditions may be different with respect to the throttle position and the engines, their availability in that specific maneuver you're talking about, correct? They're not at idle.

CAPT. CASHMAN: No, that's correct.

CHAIRMAN HERSMAN: Okay.

CAPT. CASHMAN: That's correct. And a jet engine at idle for a prolonged period will take around 8 seconds to get full thrust.

CHAIRMAN HERSMAN: Thank you. Member Weener.

MEMBER WEENER: Yeah, I'd just like to follow on the line of discussion related to stall recovery. You've said that the stick shaker gives adequate time for the crew to recover the aircraft in the case of a stall. But in this particular case, does the stall recovery require some loss of altitude or can it be done without loss of altitude?

CAPT. CASHMAN: I'm not sure what's behind the question.

MEMBER WEENER: What's behind the question is we've got an airplane with basically low speed, low power, coming up on stick shaker, and the airplane can be recovered from stalls in that condition, but in that recovery process is it necessary to trade some altitude for speed?

CAPT. CASHMAN: I think in this incident case, though, the airplane did not stall. But to answer your question, if you got into a stall or close to it at that altitude, do you have to lose altitude? And the answer is yes.

MEMBER WEENER: Okay. So the old axiom of powering out of a stall is no longer valid?

CAPT. CASHMAN: In some cases, in a jet transport, it could be hurting you if you are fully stalled.

MEMBER WEENER: Thank you.

CAPT. CASHMAN: Yep.

CHAIRMAN HERSMAN: Member Rosekind.

MEMBER ROSEKIND: Either Boeing person. There's a lot of focus on alerts here, and we've talked about some specific ones, but I'd like you to identify the formal decision making or criteria that exists for you to decide what belongs as a warning, a caution, how you decide to make it audible versus tactile versus visual, how you make sure that it's information for the pilot who's flying as well as monitoring? We've had some examples of that, but I'm curious, in your process, is there a formal decision making process and criteria for how you decide where those go?

MR. MYERS: We do have a formal process. I referred to it briefly on the slide when we first started talking about the alerting. The warnings require immediate crew awareness and immediate crew action. So that's a real high level description. And caution is immediate crew awareness and potential future actions. So as we look at each alert and we look at the range of operational conditions where it may trigger, we have to decide how to place the alert. Some issues that go into that decision are whether there are other alerts associated with that particular condition. So, for instance, in this condition, the warning event is the stick shaker, and so the caution event comes before that with a good 7 seconds-ish of time between the caution and the warning. So again, we have this whole hierarchy of information we provide to the pilot from the subtle to the drastic, and we try to make sure that there's a good progression there. We hate warnings to come up before cautions.

MEMBER WEENER: So given the time, can I ask that we get some of that information submitted for the record? So if you have a formal process with established criteria, if you could provide that for us, to decide the level of warning, what the information channel is, whether that's audible, visual, tactile, et cetera, and how it's targeted for either the pilot flying, pilot monitoring or both. So rather than take the time now, if you have that process, could you just submit that for the record?

MR. MYERS: Of course.

MEMBER WEENER: Great. Thank you.

CHAIRMAN HERSMAN: Vice Chairman.

VICE CHAIRMAN HART: Capt. Cashman, I asked you a couple of questions about the mode control panel and manual flight. I would like to know, is there a way that I could set up the mode control panel to give me a virtual glide slope, not dive and drive, but a virtual glide slope and a localizer to manually fly by following the flight director needles, a virtual constant descent approach into this airport? Is there a mode that would allow me to do that with the glide slope information failed?

CAPT. CASHMAN: Yes, there is. And, in fact, the localizer approach in use for the incident had that available.

VICE CHAIRMAN HART: So how would I set up the modes to do that, to do what I just asked?

CAPT. CASHMAN: If you just wanted to monitor it, it's on the navigation display next to the PFD. It was on there, and it comes up when you select the approach. You could couple to it in a vertical navigation mode.

VICE CHAIRMAN HART: So what approach do I select? ILS or localizer approach?

CAPT. CASHMAN: The localizer approach, with the glide slope out, it would give that a vertical navigation profile.

VICE CHAIRMAN HART: So the vertical profile would be there without me selecting anything beyond just the localizer approach?

CAPT. CASHMAN: In this particular case, that approach had it in there, yes.

VICE CHAIRMAN HART: So I could follow that and it would create essentially a virtual glide slope to be able to do a constant glide slope landing?

CAPT. CASHMAN: That's correct.

VICE CHAIRMAN HART: Okay. Thank you.

CAPT. CASHMAN: You could flight it with flight director or just look at the indicator or you could couple to it with the autopilot.

VICE CHAIRMAN HART: Okay. Thank you.

CHAIRMAN HERSMAN: Maybe it would help if you could pull up an exhibit that actually shows that? And while you're doing that, I would have one follow-up question for you all with respect to the criticality of a low speed alert. In what phase of flight do you think that is most risky or is most dangerous with respect to a failure to monitor airspeed?

MR. MYERS: So I'll answer from the perspective of a flight deck designer. We understand that --

CHAIRMAN HERSMAN: And you know what, if you either want to explain the chart that's up right now to show what was available to the crew, or we can pull the chart down and explain it later.

MR. MYERS: Actually the chart before this might be -- from a perspective of airspeed might be a little -- or I guess it's two before. Where is it? 13? Do you want to use 13? Are you asking glide path or airspeed?

CHAIRMAN HERSMAN: Virtual glide path.

MR. MYERS: Oh, virtual. Okay. So it is on that chart. On the lower left corner, there's a white scale with a magenta diamond. That is generated by the flight management computer, and it indicates to the pilot where they are relative to the flight management computed glide path.

On a localizer-only approach, the flight management computer develops a glide path that approximates the PAPI indication. And so in this particular picture, the magenta diamond, which represents the glide path, is a little bit above the pilot, who is in the center of the scale. It's a pilot-centered display.

CHAIRMAN HERSMAN: Vice Chairman, does that help? Okay, great.

Thank you for putting up that slide.

Now maybe we'll go back to the question with respect to low speed in the critical phases of flight.

MR. MYERS: Okay. So just to make sure I have the question, the question relates to the -- could you ask it again? I'm sorry.

CHAIRMAN HERSMAN: Sure. We've talked a lot about the low speed alert, and you talked about the genesis of the low speed alert being a 747 event in the mid '90s that occurred at cruise. And we're talking about this event and the design philosophy for that low speed alert, but here we're in an approach phase of flight. And so, I'm trying to get a more generic understanding.

Obviously you all look at a lot of risks when you design your aircraft. You try to design against some of those areas that might be vulnerabilities for you, and so I'm asking about airspeed and the criticality of airspeed in different phases of flight. Are there certain phases of flight where airspeed is going to be a do or die situation?

MR. MYERS: Absolutely. So when we design the airplane, we assume that aircrews are very good at monitoring when it's a critical phase of flight, when it's a relatively short duration, when it's an area of high interest, and we designed the airplane to assume that the pilots will fly the airplane when they haven't actually asked the airplane to fly.

So in the case of a final approach, we assume that is an area where the crew is actively monitoring the critical flight parameters, and there's no more critical flight parameters than glide path and airspeed. So we definitely expect that a crew flying final approach, whether it's an autoland or whether it's a manual flight visual descent, whatever -- or visual approach, we would expect them to be actively monitoring airspeed, glide path and the other critical flight parameters on the flight display.

CHAIRMAN HERSMAN: Okay. I'll leave it at that. I think probably there's going to be some discussion about what flight crews are very good at monitoring at some point in the future, but I'll leave it at that.

I'd like to go back to the parties to see if you all have any additional or follow-up questions, beginning with Asiana?

CAPT. KIM: I have one more question, Madam Chairman.

This question is for Mr. Myers. Have you ever received any complaints or comments from other pilots or airlines or anyone else regarding the wake-up function identified by the FAA and European Safety Agency?

MR. MYERS: There were two incidents that were already discussed this morning, during the 787 certification, the response to item 12 and the EASA recommendation that was done in conjunction with that one. But other than that, no, we have not received any other in-service events in the 200-million flight hours that that system's been on our airplanes. And when we went through the customer working together portion of our validation for both the 777 and the 787 subsequent to that, and we brought in crews and said, "So what don't you like about the airplanes that you have, that we need to fix?" that issue never came up.

And then we always review in-service activity in the fleet and make sure that if there's incidents in the fleet that we respond to them through our formal safety process, and we have had no incidents of the basic autothrottle modes like flight level change come into any of those formal processes.

CAPT. KIM: Thank you, Madam Chairman.

CHAIRMAN HERSMAN: Thank you very much, Capt. Kim.

CAPT. MIN: I have one question.

CHAIRMAN HERSMAN: Asiana Pilots Union.

CAPT. MIN: Yes. Capt. Cashman, when you say flight level change is not recommended during --

CHAIRMAN HERSMAN: Capt. Min, is your microphone on?

CAPT. MIN: Yes.

CHAIRMAN HERSMAN: If you could just bring it closer?

CAPT. MIN: Okay.

CHAIRMAN HERSMAN: Thank you.

CAPT. MIN: Once again, Boeing says flight level change is not recommended during the final approach. It doesn't strictly prohibit it. Would there be a reason to be able to use it? If not, why did Boeing not prohibit its use?

CAPT. CASHMAN: There are cases, for instance, with a circling approach, where the minimums are low enough that you would want to be able to do that. It's not very often encountered, but there are a few cases. In general, it would be the final approach fix, and that would be as low as we would go with it.

CAPT. MIN: Okay. Thank you, Madam Chairman.

CHAIRMAN HERSMAN: Thank you.

Air Cruisers.

MR. O'DONNELL: Madam Chairman, we have no questions. Thank you.

CHAIRMAN HERSMAN: Boeing.

MS. BERNSON: Madam Chairman, we have no questions.

CHAIRMAN HERSMAN: City and County of San Francisco?

MR. McCOY: No questions. Thank you.

CHAIRMAN HERSMAN: Thank you all. FAA.

MR. DRAKE: FAA has no further questions, Madam

Chairman.

CHAIRMAN HERSMAN: Okay. We'll go back to the tech panel.

MR. ENGLISH: Mr. Park.

MR. PARK: My question goes to Robert Myers. How many other aural caution with four beeping tones are there in the Boeing 777 system? How many other aural --

CHAIRMAN HERSMAN: Mr. Park, can pull the microphone a little bit closer to you?

MR. PARK: Yeah.

MR. MYERS: I think I heard the question. You were asking, Mr. Park, about how many caution alerts there are on the 777 that would generate the master caution quadruple chime beeper? There are -- I don't know the exact number, but it's between 70 and 80 and it varies little bit because some of them are optional features for the airlines.

MR. PARK: Okay.

MR. LeBARON: Dr. Bramble.

DR. BRAMBLE: Capt. Cashman, can you describe for us Boeing's guidance on pilot use of the autothrottle in terms of when it is expected that the pilot will use the autothrottle versus operate --

CAPT. CASHMAN: Basically we recommend -- proficiency reinforcement. But the reason we recommend it is -- there's a couple of reasons. One is that if you use the autothrottle in rough conditions, you can still set the speed at the same value, a V reference plus 5 knots. If you're manually flying, you have to increase the airspeed and add on half the wind and the full gust value to the V reference speed.

So by keeping it with autothrottle on, you're flying the approach consistently with the same attitude and amount of power. You don't have to increase the speed of the airplane for wind gusts and so on.

CAPT. COX: I'd like to bring up Exhibit 2L, page 3. This is a more precise presentation of the PFD and the ND, similar to what we were looking at earlier. This came from a simulation that very closely approximated the actual flight, and you can see at about 1400 feet, we're showing on the vertical deviation indicator about 432 feet high, and I wanted to make sure that everybody got a feel for what that VDI looks like, and I just want to readdress the question to Capt. Cashman. Is there any reason why this information should not have been available to the accident crew?

CAPT. CASHMAN: I believe it was available. As long as they had flown VNAV somewhere on the route, then this would have come up in the selection of the localizer.

CAPT. COX: And would this information have taken the flight all the way down to the runway?

CAPT. CASHMAN: Yes. Well, the endpoint is about 50 feet above the threshold.

CAPT. COX: Okay. I have one other question once again for Capt. Cashman. We talked about a number of the cues that are available to pilots to determine where they are relative to the glide path and to the speed that they're supposed to be at.

One we have not talked about very much is the pitch attitude of the airplane. Does Boeing provide anywhere in it's FCOM or other documents the characteristic pitch attitude that you would expect the airplane to be at when it's fully configured on an approach, ready to land?

CAPT. CASHMAN: Yes, we do, and I believe it's the Flight Training Manual, and we give some guidance for loss of all air data so they can fly attitude for speed.

CAPT. COX: So just once again -- I realize I'm asking you to go from memory, but can you think of probably the characteristic pitch attitude of a 777 with flaps 30 on, configured for landing?

CAPT. CASHMAN: Two to 2½ degrees.

CAPT. COX: And if a pilot's flying the airplane and he observes that the airplane is not at that pitch attitude, what inference would you expect him to make?

CAPT. CASHMAN: If he's flying level or less, I would think that that would cue him that he's flying slow.

CAPT. COX: So does Boeing expect pilots to understand the characteristic pitch attitude of the airplane when they're flying an approach?

CAPT. CASHMAN: Well, we do actually, and that's why we put it in the manual, because that information is necessary for the loss of all air data.

CAPT. COX: Okay. Thank you. That's all I have.

CHAIRMAN HERSMAN: Maybe a follow-up to the line of questioning that Capt. Cox was asking about with respect to the feel. There is feedback, correct, on the yoke? At the angle they were at, how many pounds of pressure would you have expected to be applied to the yoke to achieve it?

CAPT. CASHMAN: At which point?

CHAIRMAN HERSMAN: In the accident flight.

CAPT. CASHMAN: Well, when they were decelerating all the time, it would have been a gradually increasing force.

CHAIRMAN HERSMAN: Culminating with a maximum, what pressure?

CAPT. CASHMAN: I think somewhere -- I'm trying to remember what the flight recorder showed, but I think it was up towards 80 pounds.

CHAIRMAN HERSMAN: Eighty pounds.

CAPT. CASHMAN: Yes. The airplane, from what the data shows, was not trimmed after the autopilot was disconnected. So it could have been down to the top of the amber band. The force could have been zero. But once they entered the amber band, the force on the stick goes up by a factor of 5 for every 10 knots of speed.

CHAIRMAN HERSMAN: Okay. Tech panel, do you want to finish out?

MR. LeBARON: Yeah, let me just finish with Mr. Myers.

Member Rosekind had asked that you would provide the formal process for the level of warnings. So I ask that we make that Exhibit 2X, and that it's due by January 18, 2014.

And that's all we have.

CHAIRMAN HERSMAN: Thank you all very much, and again we appreciate everyone's flexibility on this tight day. We're going to take a number of breaks. We will now adjourn for our lunch break. We will reconvene at 12:15 for Technical Panel 2. There are food options on the promenade level. Thank you to Panel 1 for your answers and for your participation.

We're adjourned until 12:15.

(Whereupon, at 11:14 a.m., a lunch recess was taken.)

A F T E R N O O N   S E S S I O N

(12:15 p.m.)

CHAIRMAN HERSMAN: Welcome back. We'll now proceed with the second panel. I'll turn over to the Hearing Officer, Mr. LeBaron.

MR. LeBARON: Thank you, Chairman Hersman.

Witness Panel 2 is composed of the following individuals from my left, nearest the Board of Inquiry: Mr. Mike Eitel from the Federal Aviation Administration, Capt. Daren Gulbransen from the Boeing Company, Mr. Kwang-hee Lee from the Korean Office of Civil Aviation, Capt. Sung-kil Lee for Asiana Airlines, Capt. Rod McNaughton from Cambridge Communications Ltd., Capt. Byeong-geoun Yoo from Asiana Airlines.

The NTSB technical panel is composed of, starting on my right, Mr. Bill English, Mr. Jeong-kwen Park, Dr. William Bramble, Capt. Roger Cox, the panel lead, and Mr. John DeLisi.

I now ask that the witnesses please stand to be sworn. If you would raise your right hand?

(Witnesses sworn.)

MR. LeBARON: Please be seated.

Chairman Hersman, these witnesses have been prequalified and their respective experience and qualifications appear in the docket as exhibits in Group 1. I now turn the questioning over to Capt. Roger Cox.

CAPT. COX: Adam, if you would start on pulling up

Exhibit 2M, page 3 and 4.

CHAIRMAN HERSMAN: Thank you, Capt. Cox, for starting off like that. If I could just ask everyone who might be asking or answering questions, before you begin, please identify the exhibit number and page that you'd like the team to pull up. It does take a minute to pull it up. So identify the exhibit first, and that will speed things up. Thank you, Capt. Cox.

CAPT. COX: Okay. My first question will be directed at Mike Eitel. You were chairman of the Flight Standardization Board for the 777. Can you tell us briefly what is the function of this FSB?

MR. EITEL: Okay. The Flight Standardization Board is one of three functions that the Aircraft Evaluation Group handles and we are part of Flight Standards. So the FSB is the operational part and we determine pilot type ratings, the minimum training program, like checking and currency. We also conduct the initial type rating checks for the FAA, manufacturers, and possibly the initial cadre for the operators.

CAPT. COX: And I might ask you to speak a little more closely to the mic whenever speaking so everybody can hear.

When we investigated Asiana training, we found the stall protection demonstration was not a proficiency check requirement. Asiana used the demonstration provided in the Boeing Flight Crew Training Manual and -- Adam, have you found that?

It's included here in the Flight Crew Training Manual.

Can you tell me if this demonstration is consistent with the 777 FSB report?

MR. EITEL: Yes, it is. We require a demonstration of the event. If we were to do it for real, we'd have to turn off so much of the automation that it would become unrealistic -- it's unreal for the flight crews. And basically all fly-by-wire aircraft, the 777, 787 and the Airbus, fly-by-wire airplanes, have the same requirement.

CAPT. COX: Okay. Well, you anticipated my question, but I'll restate it. This is a demonstration. It is not actually hands-on flight. It is not actually a check ride requirement. Is that correct?

MR. EITEL: That's correct. It's a demonstration during the training program, not a requirement.

CAPT. COX: Could you just reiterate for me why it's not something that is checked in this airplane?

MR. EITEL: Due to the fact that we would have to turn off so much automation that it would become unrealistic for the check ride.

CAPT. COX: In the 777 FSB, did you require pilot proficiency in underspeed, that is, stall, or overspeed protections?

MR. EITEL: During the training program, obviously if it's a demonstration, you would still have to be able to demonstrate satisfactory understanding of the stall recovery maneuver and that type of stuff.

CAPT. COX: So don't let me tell you, but I want to verify whether pilots have to demonstrate proficiency in underspeed or stall in their training?

MR. EITEL: Yes. Yes, they do.

CAPT. COX: And how do they do that?

MR. EITEL: It would be through the flight training program. The training instructor would check that off, that he was proficient.

CAPT. COX: So pilots do perform stall recoveries?

MR. EITEL: Just the demonstration.

CAPT. COX: Just the demonstration.

MR. EITEL: Yes.

CAPT. COX: When the FSB approved, Mike, the 777, did you anticipate that the airplane might stall because it was in flight level change and hold mode?

MR. EITEL: No.

CAPT. COX: Can you elaborate on that a little?

MR. EITEL: Well, basically flight level change and the hold mode, like Capt. Cashman said, that the airplane is descending or going up to an assigned altitude, and in my experiences during the training program, doing check rides or operational flight, if we did have to level off at an intermediate altitude, the pilot would, if thrust started to decay, he would automatically push the throttles up to keep the airspeed where it should be or select another mode that the speed mode would engage. So that's not something that I've seen in fly-by-wire aircraft.

CAPT. COX: Okay. We talked a little bit about how Boeing pilots transition from one airplane to another earlier, but I'm interested now in any special requirements that the FSB may have put on pilots transitioning from non-Boeing airplanes with perhaps different handling, such as an Airbus. Is there any requirement by the FSB to have that kind of training done?

MR. EITEL: So an Airbus pilot transitioning to a Boeing 777 would require a full transition course, which would be the 21-day course. He'd have to meet the E and F requirements of trainer checking and then any special items we may have identified in the FSB report, and that would be tach on/tach off, full speed awareness, those types of things. But basically it's pretty much the basic airplane course.

CAPT. COX: Have you been involved in FSBs for other Boeing airplanes besides this one?

MR. EITEL: Yes, Boeing 737, yes.

CAPT. COX: Is this the first Boeing that you've seen that has a full-time autothrottle?

MR. EITEL: No, the Boeing 77 is the same, same design.

CAPT. COX: I'm sorry?

MR. EITEL: The Boeing 77 has the same design.

CAPT. COX: Okay. So the later airplane has the same design?

MR. EITEL: Yes.

CAPT. COX: Okay. Let me move now to Mr. Gulbransen. You are at Boeing training.

CAPT. GULBRANSEN: That is correct.

CAPT. COX: And what is Boeing's role in Asiana's training?

CAPT. GULBRANSEN: Boeing has a limited role in Asiana training. We have a partner, Boeing Korea, which we use a contract through CCL, Cambridge Communications Limited. Capt. McNaughton is here with us on the panel.

Boeing provides training initially to customers who purchase new airplanes. In the case of Asiana, though, we are providing a contracted piece of their training program. That is the full flight portion of their training. Asiana conducts the ground school portion and the procedures training, and Capt. McNaughton can probably speak to that or somebody from Asiana would be able to cover the details more on that.

CHAIRMAN HERSMAN: Could I ask all of the witnesses to make sure they pull their microphones close and that they speak clearly and loudly? We have translation services, but it's not just that. I think for all of us to be able to hear better, it would help. Thank you.

CAPT. COX: When you are involved in training, can you tell us a little bit of background on the kinds of training that you do and that Boeing training does in terms of the scope, the number of airlines and operators that you train and so forth?

CAPT. GULBRANSEN: So Boeing is a global company. We have a very large global group that we train. We see a lot of different experience, different operators from that world side. So when a customer purchases a new airplane, in the case of a 777 or 787, we provide training as part of that airplane sale.

Our training program, the Boeing program, if you will, is based upon FAA criteria. We also maintain curriculum for EASA and for other regulators around the world. But we teach that basic FAA, as Mr. Eitel has mentioned, to meet the requirements of that. That typical course is meant for an experienced pilot who's coming in the transport category aircraft, and as he's mentioned, based on what type of experience they have, coming from a non-Boeing glass airplane, we would put them in a transition course; and coming from a Boeing glass airplane, we would put them in a shortened transition or star course, which accounts for some commonality of Boeing procedures and systems.

CAPT. COX: Okay. Well, one of the things I was trying to focus on is the broad variety of pilots that you get to train, people across the globe, of many different cultures, of many different backgrounds. And the reason I ask about that is, I would like to have your perspective based upon your experience on the kinds of manual flying skills and the kinds of automation flying skills that you're seeing amongst the many different students that you train.

CAPT. GULBRANSEN: Okay. I could see, you know, many different aspects to that, depending on the experience of the pilot again. Just most recently, a few month ago, I had a very young first officer from, you know, a country in Asia, and they had very high automation skills. I've flown with some high time pilots from other parts of the world whose automation skills were, I would say, weaker than their manual flying skills. So the manual flying skills are something that we practice in training. We spend a good amount of time in the Boeing course covering manual flight skills, to make sure that we're covering -- showing proficiency in that with the operation of the airplane.

CAPT. COX: Have you noticed any trend in terms of the kinds of manual flying skills that pilots bring to training now?

CAPT. GULBRANSEN: I can't think of a specific trend.

CAPT. COX: And what does Boeing training do to promote active monitoring?

CAPT. GULBRANSEN: Boeing's philosophy in our normal procedures, starting out right in the beginning of a normal procedure, is to maintain the pilot responsibility, as we mentioned earlier, to maintain course, path and speed. We talk about the crew resource management part of the cockpit management, that as we make changes in our modes and changes in the automation, that we call out those changes. We recommend that that's a good crew resource management process to do that.

As we go through training, we cover the various mode changes, announce them and make sure that interface is happening, that the crew is aware of them.

CAPT. COX: Let me move to Capt. McNaughton. First, would you please explain your role and that of the other contract instructors in Asiana's training?

CAPT. McNAUGHTON: Yes. Boeing Korea has a contract with Asiana Airlines to deliver certain --

CHAIRMAN HERSMAN: Could you pull the microphone up just a little bit closer?

CAPT. McNAUGHTON: Boeing Korea has a contract, and has had a contract with Asiana for the past 12 years, to deliver a certain portion of their training, particularly full flight simulator training. The areas of training that Asiana has, to name a few, are things like initial training, transition training, recurrent training, and other types of training.

As an example, if we consider the Asiana typical transition course, there's a ground school portion which deals with aircraft systems and those types of things. There's a procedures training and then there's a full flight training portion. Each of those, the ground school is about 170 to 200 hours. The fixed base or the procedures training is approximately 20 hours. Full flight simulator is approximately 20 hours, and then that's all followed by line ops or line flying.

The portion that Boeing Korea is involved is only the fixed base portion. All the other types of training delivered to the students is done by Asiana Airlines.

CAPT. COX: Okay. So the follow-on for me is who designs the curriculum and the simulator profiles at --

CAPT. McNAUGHTON: Those are done by Asiana and provided to us.

CAPT. COX: What input do you and the other instructors have to that?

CAPT. McNAUGHTON: When it comes to the full flight simulator initial, those types of things, generally at the initial stage, we have very little involvement. However, as the instructors either use the profiles or if they're given to us with revisions, we give those to our chief flight instructor and the instructors themselves to review. If they have any questions or concerns, then those are brought forward and we deliver that to Asiana.

In the case of recurrent training, again Asiana develops the scenarios. We get those well in advance. We have the opportunity to review them, discuss them with our instructors and they, in turn, feedback to us; first to their CFI and then to the managers, and we in turn then deliver that, go back to Asiana for their consideration.

CAPT. COX: Let me focus on some specifics. Does Asiana encourage the maximum use of automation in flight?

CAPT. McNAUGHTON: They do, I believe. Their manual states, to the extent possible, to use it.

CAPT. COX: When you are conducting training in simulators, you or the other instructors, we understand that visual landings are trained in the simulator. Do you expect the pilots to be able to make visual landings without any vertical cues?

CAPT. McNAUGHTON: First, I should say that myself and the other manager, we're no longer instructing the aircraft and have not instructed any Asiana pilots. Our expectation is that the pilots, because they're coming from aircraft, they've got a good background in flying. They have a good background in visual approaches and such, and they're just transitioning to an airplane like the 777. So we expect that they would be able to fly the airplane manually.

The profiles, during the course of the training, there's a number of different visual manual flying procedures or scenarios in those programs.

CAPT. COX: Well, what I'm getting at, whether it's you that's instructing or the other instructors that are instructing, you know all of them and you kind of know what's done there --

CAPT. McNAUGHTON: Yes.

CAPT. COX: -- in the simulator. The question is how do we train pilots as to the cues that they're supposed to use to make visual approaches and landings? And so I kind of want to go down that a little bit. For instance, does Asiana train pilots to use the vertical deviation indicator when they're making approaches?

CAPT. McNAUGHTON: That's correct, they do.

CAPT. COX: Would that be in all kinds of approaches?

CAPT. McNAUGHTON: They're instructed -- as far as the instructors go, they teach the pilots to use whatever aids are available and generally to build a vertical path at all times.

CAPT. COX: I just kind of wondered, because we talked to the accident pilots and they were not aware that there was a vertical deviation indicator. They didn't recall seeing it at all. So I just kind of wondered if that was something that was emphasized during training.

CAPT. McNAUGHTON: It is something that is emphasized for sure.

CAPT. COX: What about leaving the autopilot on, on approaches to 1,000 feet? Is that customary when you're flying visual approaches?

CAPT. McNAUGHTON: I would say yes.

CAPT. COX: When the autopilot is left on to 1,000 feet, from that point on, if the airplane is trimmed, there's really very, very little input that a pilot has to make except for the player (sic).

CAPT. McNAUGHTON: That's correct.

CAPT. COX: Would you consider that to be an adequate training for manual flying skills?

CAPT. McNAUGHTON: Well, they do other types of manual flying in either recurrent training or in the transition courses, where they're set usually on the downwind leg and manual flight, no aids, and to collect the full visual approach with no aides.

CAPT. COX: So as I understand it, based upon what we've been told, there's a kind of a profile that's introduced in training that pilots are supposed to follow when they fly a visual approach. It's a downwind base and final, and that's taught over and over again.

So the question I would have would be, what does Asiana training do to give pilots the opportunity to fly other kinds of visual approaches, such as straight-in approaches?

CAPT. McNAUGHTON: Well, considering the type of airplane, especially in the 777, it's only going to major airports where you're very limited on being able to do circling approaches and such things. But generally, the pilots that transition to the airplane come from other types of airplanes where they would have had considerable background in that.

CAPT. COX: Does Asiana train pilots to use both flight level change and hold at the same time during an approach?

CAPT. McNAUGHTON: That is the choice of the pilots to what modes he will use, and that may be one of them on descent.

CAPT. COX: All right. So let me shift a little bit while I have you here. I'd like to talk about the methods that Asiana uses to ensure that new instructor pilots are able to balance their roles as the pilot in command, as the instructor, and as the pilot monitoring, multiple roles. What does the curriculum call for?

CAPT. McNAUGHTON: Well, firstly, they're fully qualified on the airplane as a captain. The instructor training program usually involves three simulator sessions which they are doing all the flying and their maneuvers from the right-hand seat. We'll set up often a scenario where on a discrete frequency they would ask the person which would be the pilot flying at that time on a takeoff to maybe do something that he would not make the proper response or the correct actions and force the instructor in training in the right-hand seat to take over. It could be a rejected takeoff or failing to rotate or something.

CAPT. COX: Would a scenario involve perhaps getting low and slow on an approach?

CAPT. McNAUGHTON: It could, but I don't know if it's specifically laid down that way.

CAPT. COX: Okay. Let me talk a little bit about Asiana's training for stalls and low speed protection. Now we've already talked about what's in the flight crew training manual. That is a demonstration.

CAPT. McNAUGHTON: Uh-huh.

CAPT. COX: And it's our understanding that Asiana does do that demonstration. Is that right?

CAPT. McNAUGHTON: That's correct.

CAPT. COX: Over and above that, what training does

Asiana give its pilots for stall recovery and low speed protection?

CAPT. McNAUGHTON: It is basically the same as laid down in the Boeing flight crew training manual.

CAPT. COX: Okay. So beyond that, Asiana does not?

CAPT. McNAUGHTON: No.

CAPT. COX: Okay. And are you comfortable with that?

CAPT. McNAUGHTON: Yes, I am.

CAPT. COX: I asked that question because other airplanes, typically we do require pilots to demonstrate proficiency in recovering from stalls.

CAPT. McNAUGHTON: That's correct. But as outlined earlier this morning in Panel 1, there's the low speed protection and the auto wake-up features of the autothrottle that should protect against those things, where the other airplanes do not have that.

CAPT. COX: I see. One final question for you. That is when pilots are asked to operate into airports that may have an irregular operation, where the threshold is displaced, where you have an angling final like an LDA --

CAPT. McNAUGHTON: Uh-huh.

CAPT. COX: -- or where you have other kinds of irregularities, and the automation simply isn't designed for that, what measures does Asiana training take to ensure pilots are skilled enough to be able to handle that?

CAPT. McNAUGHTON: Usually Asiana's training profiles are set up for airports that they operate to with that type of aircraft, and a good example would be New York. There's a lot of maneuvers and approaches using the kind of approach that would probably fit into what you're saying.

CAPT. COX: Okay. So you're saying that the Asiana pilots have the opportunity to learn these manual flying skills on visual approaches?

CAPT. McNAUGHTON: That's correct.

CAPT. COX: Okay. Let me now move to Capt. Sung-kil Lee. I believe that you are chief pilot for the Boeing 777 at Asiana. Is that right?

CAPT. LEE: Yes, I am.

CAPT. COX: We learned during our investigation that if Asiana pilots are expected normally when flying a manual or visual approach to use the autopilot down to 1,000 feet even on visual approaches. Is that basically true?

MR. LeBARON: I'm going to jump in here just a second. We've switched to consecutive translation. So what you need to do when you respond, if you could go slow, stop for the translator and then watch me. I'll tell you once the translator interprets it into English. Thank you.

CAPT. LEE: 1,000 feet is for the stable approach from autopilot to manual flying, but if the pilot wants to aviate the flight at more than 1,000 feet, I think the pilot can do so.

1,000 feet is the required minimum altitude for stabilized approach by transitioning from autopilot to manual flying skill. Even at more than 1,000 feet, if the pilot wants to change, the pilot can always turn off the autopilot and turn it to manual fly skill.

CAPT. COX: And let me ask, is a pilot punished if he flies manual approaches? Does a pilot receive negative remarks if he flies a manual or visual approach for the full approach?

CAPT. LEE: No, not at all. It never happens.

Currently, for the small and medium size airplane and domestic airplane whose flying time is within 1 hour, actually there are a lot of different types of approaches made by the pilot.

CAPT. COX: Adam, would you bring up Exhibit 2F, page 5 and 6?

The accident pilot flying got only 4 landings at San Francisco out of 29 trips, and only 12 landings total in 95 flights in the Boeing 747 over a 7-year period during the time he was flying that airplane as a first officer. Is this lower than normal?

CAPT. LEE: It has been more than 10 years since Capt. Lee Kang Kuk actually landed in San Francisco with a Boeing 747 and we are not able to give an explanation under what kind of situation he landed at SFO. However, for the airports such as San Francisco Airport, Chicago Airport or John-FK Airport, that has the characteristic of the specialty or heavy traffic or heavy workload, that case more skilled pilot is in charge of landing and takeoff. For other cases, where it is deemed as safe, then FO can take over and be in charge of takeoff and landing.

CAPT. COX: Do you keep track of the landings that pilots receive and if you find that first officers are not getting enough landings, do you take action?

CAPT. LEE: Yes. In Asiana Airlines we are meeting the requirement of the hours or times of landing and takeoff. And within Asiana Airlines we have a schedule monitoring system, so based on this monitoring, we notify each pilot if they met the specific requirements or not. And if it is known that they didn't meet the requirement, within 30 days, we arrange the schedule to reflect that status and make enough chance for those pilots to meet the required times of landing and takeoff.

CAPT. COX: Do you feel that Asiana pilots, particularly first officers, get enough airplane landings to remain proficient in landings?

CAPT. LEE: Yes, I think so.

CAPT. COX: Asiana Airlines is a long-haul airline, many flights over 5 hours, in some cases, 10 hours, which raises the question if they have enough opportunity to practice landings. What steps does Asiana take to ensure that pilots get enough practice in landings?

CAPT. LEE: As I mentioned previously, our pilots of

Asiana have to meet the required hours that is regulated by the Korean Aviation Act, and every 6 months, through BTSK, which is Boeing's Korean partner, the pilots are receiving enough chance to practice landing and takeoff through the simulator by the excellent instructors.

In particular for Boeing 777, all the captain and first officer have enough experience. They have enough experience not only for the Boeing 777 and also smaller size airplane, which is Airbus 320, and also medium size airplane of Boeing 760. In case of captain, they have 5 year experience, and first officer, they have to have more than 3 years, and both of them, they meet this requirement.

And also, it is shown in the exhibit as well. And for the Boeing 777, the first officer has enough time of the experience, and in terms of the landing, as of 2012, they met 36 percent of the landing experience.

CAPT. COX: In the case of our accident pilot, he said he felt stressed because he had to fly the visual approach without the glide slope. Can you explain why he would feel that way?

CHAIRMAN HERSMAN: Capt. Cox, can you please rephrase your question --

CAPT. COX: Let me restate. The San Francisco glide slope was out of service beginning in June, and so this information was known well in advance of the accident flight. The B777 provides a vertical profile on the navigation display for such approaches when the glide slope is not [sic] absent. The accident pilot stated he was stressed about not having a glide slope. Did you consider advising pilots to use this feature during the period that the glide slope was out of service by way of a bulletin or other advisory?

CAPT. LEE: Capt. Lee is a very well experienced pilot and his flying hours accumulated more than 10,000 hours. He also has 3,000 flying hours for Boeing 737 and he has also 5 years of experience as a captain for Airbus 320. So he has enough experience.

For example, for small size airplane and also for the domestic airlines of which the flying hours is less than 5 hours, domestic airlines and international flights which is less than 5 hours, he has experience of the time flying of 160 times a year. He was very experienced and he was a very experienced pilot for visual approach. He also has more than 10 years of experience for Boeing 747, and he also has experience of 29 times of approach to San Francisco International Airport.

All pilots make utmost effort to make it safe in the terminal area and to make safe approach.

CAPT. COX: Sir, let me just revise this question by saying, did you, as the chief pilot for the 777, have any concerns that Asiana pilots would have difficulty making an approach at San Francisco without the glide slope?

CAPT. LEE: I don't understand or I cannot tell how much stress Capt. Lee received because he was such an experienced pilot. So Asiana Airlines are providing various trainings for visual approach and also through their recurrent training which occurs every 6 months, we are providing more than 10 times of various types of landing training. And also they have to pass the requirements that is set strictly by Boeing Korea.

CHAIRMAN HERSMAN: Mr. Cox, I'm not sure he answered your question, and so please go ahead and ask it again --

CAPT. COX: Yeah.

CHAIRMAN HERSMAN: -- because I don't think it was answered directly.

CAPT. COX: Correct. I'm once again asking the question. Do you, as the chief pilot, did you feel any concern about the ability of any Asiana pilot to land at San Francisco without a glide slope indication?

CAPT. LEE: That's correct. I do not have any concern.

CAPT. COX: I'd like to direction a question to Byeong-geoun Yoo. I believe you are the director of training?

CAPT. YOO: Yes, that's correct.

CAPT. COX: I will ask you a question similar to what I asked Capt. McNaughton. What methods does Asiana use to ensure that new instructor pilots can manage their roles as both the instructor pilot and the pilot monitoring as well as pilot in command?

CAPT. YOO: Regarding the training and operation of the instructor, we have very clear standards and criteria. For those select candidates for the training that was selected by the system, we provide quality training for those people to be a highly experienced instructor, such as ground school training, simulator training and OE training.

When we select the candidates, they at least have to have 3 years of non-penalty period, and they also have to be recommended based on the system requirements. In particular, as you can see from the Exhibit 2, Uniform Section, those instructor pilots through their extensive simulator training, they are trained on various aspects of PIC, PF and PM rules so that they can have a safe flight in place.

CAPT. COX: I just wanted you to give me specific examples of what you do in training to help a new instructor understand how far he can let a trainee go.

CAPT. YOO: So I didn't quite understand your question. Can you repeat your question, please? Can you slow down and repeat your question more clearly so that I can understand your question?

CAPT. COX: Every instructor pilot must make a judgment as to how far he lets a trainee deviate from glide path, airspeed and other procedures. What specific things does Asiana do to teach new instructors how to manage this?

CAPT. YOO: Okay. Thank you very much for your question. I understood.

Regarding that, we have a clear training model and clear training programs. The instructor pilots put their first and top priority on the safety through various training procedures and also they put emphasis on improving the proficiency or ability of the trainees, and to this end, we have various courses in place.

So during the flight training, if there is a deviation for the first time, the trainee will get some notice and warning from the instructor saying that there's a deviation. And if this deviation happens more than twice, then the instructor will actually take over due to the safety issue.

CAPT. COX: Okay. For my final witness, Mr. Kwang-hee Lee. You are a manager for the Korean Office of Civilian Aviation. Is that right?

MR. LEE: Yes, that's correct.

CAPT. COX: Does your agency, the Office of Civilian Aviation, conduct check rides and observations of Asiana flights or does your office delegate these activities to Asiana?

MR. LEE: Not just because of this accident, but at Korean Office, KO, we always supervise and oversee the airplane and operations. Based on our annual, monthly and weekly plan, we have this continuous oversight system in place through our supervisor. So even at this exact hour, our monitoring is still going on.

CAPT. COX: Are the Korean Aviation Regulations available in English?

MR. LEE: Yes, there is an English version for that, but as to whether there's a latest version to that or not, I need to look into it.

MR. LeBARON: Mr. Cox, the panel, we're out of time.

Mr. Park, if you can, limit your question just to one at this point. We may have time when we come back around.

MR. PARK: I would like to ask Capt. Yoo of Asiana for Asiana, the highly automated flight training, Asiana introduced simulator from Boeing, the Boeing simulator training, for that, is Boeing directly involved or not?

CAPT. YOO: Our company's full flight simulator training is conducted by Boeing Korea. The pilots actually put down some of the actual cases on their notepad because there's some unexpected situations happen.

MR. PARK: I will repeat my question from the beginning.

According to the interviews for the accident aircraft pilots and other pilots, when autothrottle is hold mode, the throttle is not automatically supported, and this fact was not so much well known amongst the pilots and some pilots actually had the situation happen unexpectedly and they have such cases put down on their notepad. Why did pilots know that this is unexpected situation and did not so much well know about this? Can you explain the reason behind this?

CHAIRMAN HERSMAN: Who is your question directed to?

MR. LeBARON: Who's the question for?

MR. PARK: To Rod McNaughton, please, Capt. Rob McNaughton please.

CAPT. McNAUGHTON: I'm sorry. I was not sure who the question was directed to. Could you please restate it?

CHAIRMAN HERSMAN: Actually, I think if we could just get the interpreter to restate it. Go ahead if you could. Thank you to all of the interpreters for their hard work.

MR. PARK: So basically according to the interviews with the accident aircrafts and other pilots, they said that if the autothrottle is in the hold mode, the throttle is not supported automatically, and they did not know this fact that much. So I just wanted to know -- and some of the pilots actually had this happen unexpectedly and they had that down in their notepad because it was an unexpected situation for them. So he was just wondering why these pilots did not know so much about this fact and why did they think this was unexpected situation?

CAPT. McNAUGHTON: Well, first, when the pilots get to the full flight simulator training, our expectation is that that's been covered in systems ground school and procedures training, and they should be aware of it. We deliver the full flight portion, the profiles and the scenarios set out by Asiana, and if the instructor at any time notices an area where the student is not familiar with or is not clear, we would expect the instructor to bring that to their attention.

The scenarios that are used in full flight may not necessarily directly relate to that particular thing you mentioned, but again, our expectation is that the students would have knowledge of that prior to getting to the full flight simulator.

MR. LeBARON: Chairman, the tech panel is finished.

CHAIRMAN HERSMAN: Thank you. We'll move to the parties. Asiana.

CAPT. KIM: Thank you. I have a question for Capt. Yoo, Byeong-geoun Yoo. I have two questions. Does the Asiana training program prepare pilots to fly visual approaches without glide slope?

CAPT. YOO: Can you repeat the question?

CAPT. KIM: Does the Asiana training program prepare pilots to fly visual approaches without the glide slope?

CAPT. YOO: Yes, I think so.

CAPT. KIM: Have you personally ever heard an Asiana pilot express reluctance to perform visual approach?

CAPT. YOO: Can you repeat the question?

CAPT. KIM: I'll ask you slowly. Have you personally ever heard an Asiana pilot express reluctance to perform visual approach?

CAPT. YOO: I would like to answer in English, but there is no such case. I would like to ask you in English, for Asiana Airline pilots, have you ever listened to any expression that Asiana Airline pilots lack of proficiency? No, out of 1360 pilots, half of them had military experience and half of them come from the civil industry. So those 50 percent of the people who are coming from the civil sector all have FAA's private commercial license and many of them have already trained in the United States based on the U.S. program.

CAPT. KIM: All right. Thank you, Madam Chairman.

CHAIRMAN HERSMAN: Asiana Pilots Union.

CAPT. MIN: Yes, Madam Chairman.

Mr. Yoo, Byeong-geoun, one of the Asiana training, simulator training program, when the autothrottle was in hold mode and the flight level change mode, have you ever experienced a low speed flight?

CAPT. YOO: No. Actually there is an item like explaining the general hold mode, but there is no specific item.

CAPT. MIN: If no, are you totally dependent on FCOM's note?

CAPT. YOO: Yes, I do.

CAPT. MIN: Capt. Gulbransen, is there a situation in descent or approach phase where you would use flight level change versus vertical speed?

CAPT. GULBRANSEN: I couldn't quite understand. Please repeat.

CAPT. MIN: Is there a situation in the descent or approach phase where you would use flight level change versus vertical speed?

CAPT. GULBRANSEN: If I understand, is there a situation in a descent where you would use flight level change versus vertical speed? Is that correct?

CAPT. MIN: Yes.

CAPT. GULBRANSEN: Okay. So we use flight level change, as was explained in Panel 1, to change from one level to another. So in a descent or an approach, setting a lower altitude and then descending to that altitude with flight level change is a normal use of flight level change.

In the execution of that portion of an approach, you would expect the flight level change mode to change, be annunciated, and you would also expect the throttles to go to idle in relation to the amount of change you have to make for that altitude and set the thrust accordingly, and the thrust could end in hold.

You could also use vertical speed as a different mode to descend, a different vertical mode, and use the vertical speed portion of the descent. That's up to the pilot, to their use of the automation.

CAPT. MIN: I have one other question, Capt. Gulbransen. As a hypothetical, you are flying a visual approach manually, speed at 210 knots, speed brake deployed, at 1,500 feet. You find yourself significantly above the approach path and fast. How do you set the autothrottle to assist you in the approach?

CAPT. GULBRANSEN: So your energy state is high and fast. You have your speed brake out. You're trying to slow down, and the autothrottle is what you're asking for. So what mode is the pitch in at this point?

CAPT. MIN: Manual.

CAPT. GULBRANSEN: So you're manually flying the airplane.

CAPT. MIN: Yeah.

CAPT. GULBRANSEN: If you bring the throttles back to idle and there is an active mode of the autothrottles, if the pilot is taking control of the throttles, the expected mode on the autothrottle would be to go to hold. Does that answer you question?

CAPT. MIN: Yeah, okay.

CAPT. GULBRANSEN: That hold annunciation, when it makes that transition, that would be annunciated with a green box around that new mode annunciation to draw the pilot's attention. We would also teach that the pilots would call out that mode change so that the other crew member was aware of the change and the pilots are aware of the fact that they're in hold and what that means in relation to the autothrottles.

CAPT. MIN: Okay. Thank you for your answer.

Okay, Mr. Yoo, Byeong-geoun, when the pilot instructor during the flight did some training or evaluation, among PIC, PM, and IP, which one comes the first as responsibility? What is the order or sequence among those three?

CAPT. YOO: The pilot in command comes the first.

CAPT. MIN: Capt. Gulbransen, does Asiana use Boeing procedure used to fly the Boeing 777 or have they modified any procedure?

CAPT. GULBRANSEN: Again, I'm not completely familiar with the Asiana program, but from what I understand, they use the combination of Asiana's Pilot Operating Manual and the Boeing Flight Crew Training Manual, but perhaps that could be better answered from Asiana.

CAPT. MIN: APU has no more questions. Thank you.

CHAIRMAN HERSMAN: Thank you.

Air Cruisers.

MR. O'DONNELL: Madam Chairman, we have no questions. Thank you.

CHAIRMAN HERSMAN: Boeing.

MS. BERNSON: Capt. Gulbransen, does Boeing provide guidance and training on stabilized flight criteria that need to be achieved during landing approach?

CAPT. GULBRANSEN: Yes, we do. In the Flight Crew Training Manual, we adopt the standard stabilized approach criteria set up by the Flight Safety Foundation. There's criteria for altitudes based at 1,000 feet for an instrument approach and again for 500 feet for a visual approach. Clearly laid out criteria -- I believe there's seven of them -- things as course, path, speed, throttles in the correct position, checklist completed. And that's a continuing monitoring system by the pilot to follow those stabilized criteria all the way to landing; 500 feet being the part you would check to make sure you're stable, and if they degrade at any point, the criteria is clearly spelled out that a go-around is expected.

MS. BERNSON: Thank you. Capt. Gulbransen, we have a follow-up question. There's been a lot of discussion about unexpected behavior with autothrottle and hold. As a check airman, what would you have expected the student to do if he was surprised by autothrottle in hold?

CAPT. GULBRANSEN: In the procedures in the Flight Crew Training Manual, again, we discuss the use of automation and the pilot's choice to use as much or as little as they want. When the automation is not doing what they expected or are surprised, to use a phrase that has been passed around, we expect that the pilot would take control of the airplane and use whatever skills that they needed to do to fly the airplane manually, and that would include reducing the automation, or in the case of a throttle being in hold and not responding to a decreasing airspeed, you would expect input in the throttle to maintain that speed and to maintain your three basic parameters of course, path and speed.

MS. BERNSON: All right. Thank you. Boeing has no further questions.

CHAIRMAN HERSMAN: Thank you.

City and County of San Francisco.

MR. McCOY: Madam Chairman, we have no further questions or no questions at all. Thank you.

CHAIRMAN HERSMAN: Thank you.

FAA.

MR. DRAKE: Madam Chairman, FAA has no questions.

CHAIRMAN HERSMAN: Okay. We'll proceed to the Board Members. Member Weener.

MEMBER WEENER: Thank you. I'd like to pursue a bit what the process is for training an instructor. So Capt. Byeong-geoun Yoo, how do you identify and choose candidates for instructor pilots?

CAPT. YOO: Asiana has a clear guidance and standard to choose the instructor pilot. According to the certification by Korea's MOLIS (ph.), based on the FSR, there is a criteria specified to be selected as academic instructor and a simulator instructor and a flying instructor. Among those who qualify for this criteria, we actually selected twice as many number of instructor pilot that we need and then we just verify those personnel's qualification and then we select the appropriate instructor pilot.

The flight instructor's translation [sic] consists of the academic training, including instruction and leadership and IPCCLM, and then it is followed by the simulation training. For the simulator training, a total of 10 trainings are made for PF, PM, PIC so that the instructor pilot can have various backgrounds and experiences. Other than the instruction about the visual approaches, also included and when the student pilot does not control the airplane properly, then the instructor pilot can actually correct the student pilot's action and take over and make go-around.

In actual operating experience, operating experience of the instructor pilot actually instruct the student pilot sitting on the right seat while sitting on the left seat, and the instructor pilot have to pass the various experience and test and check. Even after becoming the instructor pilot, every year the instructor pilot must fulfill the proficiency check and CLM to maintain its instructor pilot's status.

MEMBER WEENER: Does Asiana have any requirements or rules about pairing a fresh instructor with a basically fresh captain?

CAPT. YOO: As the instructor pilot is already selected among those who fully qualify to become the instructor pilot, so there is no criteria regulation to pair the new instructor and the new pilot.

MEMBER WEENER: Thank you.

CHAIRMAN HERSMAN: Member Rosekind.

MEMBER ROSEKIND: Capt. Yoo, would you give us a sense of how you compare the effectiveness of the Asiana training program with others around the world? Not compliance, but effectiveness of your training program compared to others. How do you do that?

CAPT. YOO: In terms of effectiveness, all Asiana's training program meets or satisfies the international standard such as FIR and EASA, and the Asiana training program is meeting the standards of FSR, which is equivalent of the Korean FIR.

In terms of ground skill training and simulator training, we are trying to meet the standard of a very good program with consultation with the manufacturer, Boeing. So we are meeting the criteria of the good standard program in cooperation with the manufacturer, Boeing, FCOM, FTC, and in particular, simulation of full flight. In order to improve our training quality for the safety operation, we have made a relations or contracted with Boeing Korea since 2001 for better program.

MEMBER ROSEKIND: So basically --

CAPT. YOO: Yes, it is well above the international standard. Yes, it exceeds the international standard.

So personally, in 1990, I received training for the Boeing 737 in the United States from the Continental Airlines and, in 1993, in order to transition to Boeing 747, I received training from Lufthansa Airlines. So I believe that I am well aware of the international standards and also that gives me the chance to compare those international standards to our domestic standards.

So in case of Asiana, we are providing training through ground school, simulator and OE and CRM and, in particular, regarding simulator, we are providing the training through Boeing which is a well-known training institution since 2001.

CHAIRMAN HERSMAN: Vice Chairman.

VICE CHAIRMAN HART: Thank you. I'd like to ask Asiana, either Capt. Lee or Capt. Yoo, about the previous reference to a visual approach from downwind. So in a visual approach from downwind, what are the responsibilities of the pilot flying and what are the responsibilities of the pilot monitoring? When I ask that question, I mean what is trained in your training regarding the responsibilities of the pilot flying and the responsibilities of the pilot monitoring in a visual approach from downwind?

CAPT. LEE: So the responsibility between two pilots are divided by the responsibility by the pilot flying and the responsibility of the pilot monitoring.

So for the monitoring pilot, instructor pilot has to assert authority and power or responsibility starting from the moment of the departure and to the moment of arrival. So in case of instructor pilot, either he's serving as PF or as PM, he has the final authority. So when he identifies the abnormal flight path or abnormal situation, he commands correction to the pilot flying and if the correction is not made by pilot flying, then the monitoring pilot takes over and has the full authority to operate the airplane.

VICE CHAIRMAN HART: What is the training regarding the pilot monitoring calling out deviations from expected performance?

CAPT. LEE: Can you repeat the question, please?

VICE CHAIRMAN HART: Yes. What is the training regarding what callouts the pilot monitoring should make? What should the pilot monitoring do, to bring to the attention of the pilot flying, that the pilot flying is deviating from expected performance?

CAPT. LEE: So the monitoring pilot when he identifies deviation, in either flight paths or flight control or ACT, he makes callout in a clear way to pilot flying so that he can be aware of the situation, and he recommend the correction. And when the correction is not made, the monitoring pilot enforces the callout again.

VICE CHAIRMAN HART: And that question was in regards to automation during the visual approach from downwind.

CAPT. LEE: So according to our training, pilot flying is in charge of aircraft control and pilot monitoring is monitoring the flight path or other situations, such as final course and airspeed and sink rate. When pilot monitoring identifies some deviation in these areas, then he makes out the standard callout to make correction to the pilot flying. And then if the correction is not still made by the pilot flying, then pilot monitoring makes another standard callout again to enforce that callout, and if the correction is not made at that point either, then for safety reason, the pilot monitoring takes over and is in charge of flight.

CHAIRMAN HERSMAN: Thank you. I'm going to try to ask some basic questions. First, just a yes or no answer. Do you all train on stabilized approach? Boeing. Yes or no?

CAPT. GULBRANSEN: That was for Boeing? Yes, we do.

CHAIRMAN HERSMAN: Okay. And in the simulator, yes.

Asiana, do you train on stabilized approach?

CAPT. LEE: Yes.

CHAIRMAN HERSMAN: Could you tell me what the indicators are of a stabilized approach?

CAPT. LEE: Can I answer to your question? It is clearly stated in the pilot operation manual about the stabilizer and it is divided --

CHAIRMAN HERSMAN: Can we get the English translation please?

INTERPRETER: Can he repeat his answer please?

CAPT. LEE: If it's okay, I speak English.

CHAIRMAN HERSMAN: Yes, please, proceed.

CAPT. LEE: For the stabilizer approach, we follow the KOCARs, approved the POM, Pilot Operation Manual. It involves VFR, visual flight rules, and IFR, instrument flight rules. In case of instrument flight rules, for the ILS approach --

CHAIRMAN HERSMAN: How about if we just about a visual approach?

CAPT. LEE: Yeah, visual approach, in case of visual approach, at 500 feet, we satisfied six items: aircraft on the correct course and the path and the sink rate within 1,000 feet, and on speed, within plus 10 knots minus 5 knots, and all landing configuration is done and landing clearance is received.

CHAIRMAN HERSMAN: Okay. So what cues do they use to establish that they are on a stabilized approach inside and outside of the cockpit? What tools are they going to be using for speed and for glide path?

CAPT. LEE: During the visual approach and IFR approach, monitoring is very important inside and outside. Also we can have that information from POM, Pilot Operation Manual. The load is divided by PF and PM.

CHAIRMAN HERSMAN: Okay. So let's focus on let's say external to the cockpit, when they're looking at glide path and they might be using the precision approach path indicators, or the PAPIs. When you're training for a stabilized approach, what are your expectations if the pilots see on the PAPI three red? Would they have to go around?

CAPT. LEE: Two red or too high is own pass.

CHAIRMAN HERSMAN: If they see three red, what's required?

CAPT. LEE: It depends on the situation. If the path angle is a little bit high because of the tolerance or something like that, and just a few seconds, it happens then, the pilots increase correction, then immediate correction. This kind of thing should be briefing during people initiate the final approach calls.

CHAIRMAN HERSMAN: What if they see four red?

CAPT. LEE: Four reds, immediate go-around. Immediate.

CHAIRMAN HERSMAN: Okay. If they see three red, should they talk about it? Should they discuss that they're low, three red?

CAPT. LEE: In case of three red, should talk, should talk. PM can tell "three red, three red" like this.

CHAIRMAN HERSMAN: Okay.

CAPT. LEE: Then PF should take immediate action.

CHAIRMAN HERSMAN: Okay. Adam, could you please pull up Exhibit 13B, the last page?

On this exhibit here, at the very bottom of the page, you can see the calculated pilot eye height. You can see the whites and the reds depicted on the left side. You can see a band of red that's 19 seconds where the pilots were in three and then four red. You can see the red line at the very bottom that indicates four red. We have interviews in Exhibit Number 2B where both the pilot flying and the pilot monitoring indicated that they saw three or, for another pilot, four reds.

What would you have expected from training to happen when that occurred, when they saw three or four red?

CAPT. LEE: In case of three red, then immediate three, warn the PF, "three red, three red" like this. In case of four red, immediate go around.

CHAIRMAN HERSMAN: And from the cockpit voice recorder, do we have any indication that those conversations took place?

CAPT. LEE: No, the callout is where -- establish it from time of listen, I think not fully satisfy our standard callout.

CHAIRMAN HERSMAN: Okay. Thank you.

Member Sumwalt.

MEMBER SUMWALT: Thank you. Adam, if we could have Exhibit 2M, 2 Mike? And, Capt. Gulbransen, this is for you.

I'm going to ask about the section of the 777 Flight Crew Training Manual in the stall protection demonstration and I'm not sure that you can even read that, what's there, but I want to say really I'll read some of this. The objective of the stall protection demonstration is to familiarize the pilot with the stall warning and correct recovery technique.

Now it talks about how to set up the configuration, and in about the third line, second or third line, it says, "disengage the autopilot and autothrottle and retard the thrust levers to idle." So it's saying disengage the autopilot and thrust levers, so the autothrust is completely disengaged at that point. Is that correct?

CAPT. GULBRANSEN: The autothrottle system is still on, but the throttles are disengaged, disconnected.

MEMBER SUMWALT: What was the first part of what you said? I could not hear that.

CAPT. GULBRANSEN: The autothrottles are still armed, the switch is on the mode control panel.

MEMBER SUMWALT: Yeah.

CAPT. GULBRANSEN: The system is armed --

MEMBER SUMWALT: Okay.

CAPT. GULBRANSEN: -- but the throttles are not engaged in the mode.

MEMBER SUMWALT: So when you take the autothrottles and you retard them, and let's say that you hold them at the idle stop for, say, 1.1 seconds, 1.5 seconds, what will the mode annunciation be for the autothrottles?

CAPT. GULBRANSEN: Well, in the case of this demonstration here, you've disconnected the autothrottles, so there will be no mode to see a hold or anything like that at that point.

MEMBER SUMWALT: Okay. You disconnected them with the --

CAPT. GULBRANSEN: The mode will be blank.

MEMBER SUMWALT: Okay. All right.

CAPT. GULBRANSEN: And you'll get -- so that's the answer.

MEMBER SUMWALT: Great. As we go through this, it talks about as the speed decreases into the amber band, the pitch limit indicator appears on the primary flight display. When the speed deceases approximately halfway through the amber band, the airspeed low caution message appears, the autothrottle wakes up and automatically engages in the speed mode and returns the airplane to the minimum maneuvering speed.

Just reading this, it would indicate that the throttles do have the ability to wake up. Where does it caution that if you're in a flight level change mode and the autothrust is in hold, that they will not wake up as we've just described here?

CAPT. GULBRANSEN: So specifically I believe it's in Chapter 4 of the Flight Crew Operations Manual, a note that says in flight level changes, the mode -- that the throttle's in hold, it will not wake up.

This is a case demonstrating the fact that when there is no active autothrottle mode, meaning that that mode window is blank, that this is a case where the autothrottle system will activate to put it into a mode to protect is against speed.

MEMBER SUMWALT: See, if you know all of those nuances, it's pretty clear, but here we are training people and we're instilling in them that the autothrottle is going to wake up.

CAPT. GULBRANSEN: Okay. Waking up meaning that there is no active mode. Hold is an active mode of the autothrottle system, and the definition of hold is that the servos are disconnected and the pilot has manual control of those throttles. And that mode is annunciated with a green box around that mode window when it changes.

MEMBER SUMWALT: It's annunciated for 10 seconds, correct?

CAPT. GULBRANSEN: Correct.

MEMBER SUMWALT: Okay. With the green box around it, okay. Thank you.

Capt. Yoo, annyeonghaseyo. I'd like for Exhibit 2N, page 6. And here we have from the training slides on stall protection and autothrottle modes for Asiana Airlines.

In this slide, it's talking about the stall protection features and the fourth bullet point is in yellow, whereas the other ones are in black. And that bullet point says, "Autothrottles engage automatically (if armed)."

Is that slide highlighted in yellow, is that always highlighted in yellow when you show it, or is it highlighted just for this exhibit to make a point?

CAPT. YOO: So far we have been actively cooperating with NTSB's requests and we produced many, many different materials. So to the best of my knowledge, I really can't tell you either way, and I would have to get back to you as to what was the real case.

MEMBER SUMWALT: All right. But this is what you're teaching your pilots, is based off of this slide, correct, that the autothrottles engage automatically if armed? This is what you're teaching?

CAPT. YOO: Yes, that's correct. Our flight instructors manufactured this slide, created this slide based on Boeing's

Flight Crew Operation Manual and Boeing Flight Crew Training Manual.

MEMBER SUMWALT: We'll not call for the exhibit, but when you were interviewed by the NTSB, it happens to be Exhibit 14A, page 14, we don't have to call it up, but I believe you said that neither the 777 training module on automatic flight control system nor the Boeing 777 flight control recurrent training indicated that low speed protection function by the autothrust would not activate if it was in the hold mode. So if it's not covered specifically in training, how do you expect your pilots to be aware of it?

CAPT. YOO: Since 2001, as we have been operating Boeing 777 aircraft, our instructor pilots accumulate a great deal of experience. So we reflected that experience onto our training materials. So the basic material for our training in terms of Boeing 777 is FCOM and FCTM but also we created CBT training materials and et cetera, so that we can keep up the quality training for our pilots and instructor pilots.

MEMBER SUMWALT: Thank you very much.

Capt. Lee, would you agree that your instructor pilots are your most skilled pilots?

CAPT. LEE: I mostly agree, yes.

MEMBER SUMWALT: How do you explain that the instructor pilot who was on the accident flight said that when he was -- when the instructor pilot was asked if the 777 had automatic speed protection function, when it reached minimum speed, he said there was such a function and he knew about it, and the training captain basically said that he expected the 777 autothrottle system to come out of idle to prevent it going below minimum speed. How do you explain that your instructor pilot, who you've just said is one of your most skilled pilots, and a new pilot who has just come out of ground school -- okay, so what I want to know is how are you sure that your pilots are adequately trained about the knowledge of this autothrust system?

CAPT. LEE: For Asiana Airlines pilots, they went through ground school training, which over-met the international standards in terms of getting trained on autoflight and autothrottle system.

MEMBER SUMWALT: But we've just said, though, that your training does not cover this system.

CAPT. LEE: Yes, that's correct. In terms of the flight level change hold mode, we accumulated various types of experience by our instructor pilots. So we reflect that experience in our training, and also the flying pilot of the accident aircraft received that training.

Also, as Capt. Yoo mentioned, our ground school program, our full flight simulator training, and our various training programs are based on the Flight Crew Training Manual and Flight Crew Operation Manual by Boeing. So based on that, we create our materials and training schedules or plans.

According to Boeing's recommendations, we have a lot of various stall protection and simulation program and this program is also made at the ground school and supported by the BTSK so the pilots can experience a lot of stall protection and low speed protection training.

However, in terms of the hold mode, unfortunately in the Flight Crew Operation Manual and Flight Crew Training Manual, the training about the hold mode is not seriously recommended. And not only Asiana Airlines, but also for other airlines, I don't think there was a simulation training for this, related to this issue in terms of hold mode.

CHAIRMAN HERSMAN: Thank you.

We'll go back to Mr. Park.

MR. PARK: I have a question to CCL, Rod McNaughton, instructor. I asked the question before when the autothrottle was hold in mode, the throttle was not automatically supported and the pilot stated that they did not know about this fact. But regarding this issue, in the manual about this issue, this is clearly described.

CAPT. McNAUGHTON: As mentioned earlier, our expectation would be that when a pilot came to full flight simulator training, they would have adequate knowledge from their ground school and their fixed base procedures trainer on the various modes of the autothrottle. And the instructors, during the course of the training, if there was any indications that they did not understand that, then they would bring it to their attention or discuss it with them and debrief on it.

The training material is prepared by Asiana in according with their training regulations, and they put the content into the profiles which basically mirrors what's in the Boeing Flight Crew Training Manual.

MR. PARK: In which part of the manual? Can you please specify in which part of the manual this issue is described? Can you please specify?

CAPT. McNAUGHTON: I cannot give you the specific page number. I know Capt. Gulbransen can do that. But it's in the Flight Crew Training Manual.

CHAIRMAN HERSMAN: Is there another witness who can provide that information?

CAPT. GULBRANSEN: Yes, perhaps I can speak to that. In the use of, if I understand your question correctly, the hold function; is that correct?

MR. PARK: Yes. The question is that in the hold mode, the hold mode is not waking up, the throttle is not operated. So is this specifically described in the manual for the pilot's simulation training?

CAPT. GULBRANSEN: Correct. In the Flight Crew Operations Manual, in Section 4, is the description of the autoflight system, autothrottle system. Hold is one of those modes that say inactive mode, and so it's described in there.

It's described in Section 4.20, I believe, the fact that if you're in flight level change, that hold is an expected mode and that hold would mean that the throttles are not active.

I think if we went back to the slide we had earlier -- can we please pull that back up, the training slide you had -- no, okay.

In that case the discussion was would the throttles wake up, and in that FMA, was the blank autothrottle mode, meaning there was no active mode. And that is as described in the FCOM -- not the -- the CBT slide. But that is a case where there is no active mode, and that is the case where it's described that the autothrottle will wake up and put the airplane in speed mode.

Does that answer your question? So in this case right here, the upper left FMA is blank. There is no throttle, autothrottle controlling mode and that is the situation described when the autothrottles will wake up and activate, if they're armed, as the slide depicts.

MR. PARK: I think I will deal with this issue in Panel 3.

I have question to Capt. McNaughton, my last question.

I think you are in charge of Asiana pilot simulation training. Do you think there are any insufficient or inadequate areas in terms of like simulation training for Asiana Airline pilots?

CAPT. McNAUGHTON: I think Asiana adequately covers the required training scenarios and what's provided, or what's necessary for the pilots to complete transition course.

MR. PARK: Okay.

CHAIRMAN HERSMAN: Do the parties have any follow-up questions? Asiana.

CAPT. KIM: I have a question, Capt. Byeong-geoun Yoo.

Did the pilot flying, Capt. Lee Kang Kuk, training, receive training on the use of the flight level change mode and the potential for the autothrottle to go into hold mode during such an approach?

CAPT. YOO: When Capt. Lee Kang Kuk made such approach, does he know that when he used the flight level change, does he know that autothrottle goes to the hold mode? No. There's no general training about the hold mode, but it's in particular like when a specific situation arises, the autothrottle is tripped. Regarding this issue, there's no general training.

CAPT. KIM: Capt. Lee Kang Kuk, when he used the ground skill in terms of like risky factors, when he approached the San Francisco Airport, has Capt. Lee Kang Kuk ever received a training regarding the riskiness of approaching the San Francisco Airport?

CAPT. YOO: Yeah, as for the question, yes, has Capt. Lee Kang Kuk received the training, and regarding the training, Exhibit Number 2D actually proved my answer.

CAPT. KIM: That's all.

CHAIRMAN HERSMAN: Asiana Pilots Union.

CAPT. MIN: APU has no more questions. Thank you, Madam Chairman.

CHAIRMAN HERSMAN: Thank you. Do any of the other parties have any additional questions? No.

We'll go back to the tech panel. Mr. LeBaron.

MR. ENGLISH: Just two points or order, Madam Chairman, that I'll just take for Tim. This is for Mr. Lee of KOCA. You mentioned during one of your answers, and I wanted to make sure this is correct, that you believed that there is a set of Korean Flight Safety Regulations that is in the English language but it is not necessarily current. Is that correct?

MR. LEE: I said that there was an English version, but I have to check if the English version is the most latest version because Korean comes first, and the Korean regulation actually changes frequently. So I'm not quite sure if the English version is the most latest, and I have to check to make it clear.

MR. ENGLISH: Thank you. Will you please provide to the NTSB the latest version of the Korean regulations in the English language by the due date specified by Mr. LeBaron, January 18th?

MR. LEE: Yes, I will.

MR. ENGLISH: Thank you. The second point of order is for Capt. Yoo of Asiana. You mentioned a slide was up on the board about the training slides, ground school training slides that Member Sumwalt asked you about, and you needed to confirm if the yellow highlight was actually in existence prior to the accident or not. Will you please confirm that the exhibit as we have it now is the pre-accident version of the ground school training, just to make sure you can confirm that to us by January 18th?

CAPT. YOO: Yes, I will.

MR. ENGLISH: Thank you. Nothing further.

CHAIRMAN HERSMAN: Thank you all on Panel 2, and we will take a break until 2:30.

(Off the record at 2:13 p.m.)

(On the record at 2:30 p.m.)

CHAIRMAN HERSMAN: Welcome back. We'll now proceed with the third panel of today's hearing. Mr. LeBaron.

MR. LeBARON: Chairman Hersman, Witness Panel 3 is composed of the following individuals, from my left, nearest the Board of Inquiry: Dr. Kathy Abbott from the Federal Aviation Administration, Mr. Stephen Boyd from the Federal Aviation Administration, Capt. Dave McKenney from International Federation of Airline Pilots Associations, Mr. Bob Myers from the Boeing Company, and Dr. Nadine Sarter from the University of Michigan.

The NTSB technical panel is composed of, starting on my right, Mr. Bill English, Mr. Jeong-kwen Park, Dr. William Bramble, the panel lead, Capt. Roger Cox and Mr. John DeLisi.

I now ask that the witnesses please stand to be sworn. Please raise your right hand.

(Witnesses sworn.)

MR. LeBARON: Chairman Hersman, these witnesses have been prequalified and their respective experience and qualifications appear in the dockets as exhibits in Group 1. I now turn the questioning over to Dr. William Bramble.

DR. BRAMBLE: Good afternoon. Panel 3 will address effects and influence of automation on human performance, and we will begin the questioning with Dr. Nadine Sarter from the University of Michigan.

Dr. Sarter, you're an expert in human performance and automation related issues. Could you please describe for us the positive and negative effects of automation on human performance?

DR. SARTER: That's correct. The positive and negative effects of automation on human performance, obviously we know that automation can be extremely supportive of human operators if it is designed properly. It can help perform tasks that a human might not normally be capable of even performing on their own. So in that sense, properly designed automation is a very support thing for human performance.

But we also have seen in a number of incidents and accidents that, if not designed in a certain way, automation can actually get in the way. We have heard things like clumsy automation, where automation is designed in such a way that it helps the most when the pilot actually might need the help the least, but when they need the help the most in very time critical conditions, it might be very difficult for them to actually operate the automation, instruct the automation. So in that sense, it can actually get in the way if you were in those kind of circumstances.

So it depends on the --

CHAIRMAN HERSMAN: Dr. Sarter, could you pull the mic just a little closer?

DR. SARTER: Oh, sure. So I would say that the effect that the automation has depends to a very large extent on its specific implementation and the specific task that it's being designed for as well as the level of autonomy that you assign to the automated system.

DR. BRAMBLE: What types of errors are commonly associated with the use of autoflight systems?

DR. SARTER: One of the most well known and most discussed ones would probably be mode errors. Mode errors basically being a failure in mode awareness, where mode awareness is the knowledge and understanding of the current and future state of the automation, and a mode error would then mean that you perform an action that is appropriate for the assumed state of the automation.

MR. LeBARON: Dr. Sarter, could you slow down just a little bit for the translation please?

DR. SARTER: I will do my very best.

MR. LeBARON: Thank you.

DR. SARTER: Thank you. So mode awareness basically being that you are aware of the current and future state of the automation, and if you're not, then that might lead to a mode error where you perform an action that is appropriate for the assumed but not for the actual state of the automation.

DR. BRAMBLE: Are these types of problems, mode errors and mode confusion, are they unique to one particular airplane manufacturer?

DR. SARTER: No. As a matter of fact, if you look across incidents and accidents and the research that has been conducted, these types of problems have been observed on a large number of different flight decks in lots of different circumstances and again repeatedly shown for various types of pilots at different levels of experience.

DR. BRAMBLE: What factors influence the probability of such errors?

DR. SARTER: The most often discussed and most studied ones would be, one factor is called observability, which is contrasted with what we call data availability. In other words, you might provide all the data that the pilot may need, but if you don't do it in such a way that it is preprocessed and properly presented to the pilot, then all you achieve is data availability and what you need is observability.

Another one that has often been discussed and mentioned today as well is misunderstandings or misconceptions in a pilot's mental model of how the automation works. Another one would be the high level of complexity and coupling of the automation. And then finally, the one I mentioned earlier, which is a very high level of autonomy of the automated system.

DR. BRAMBLE: Have you studied the visual scanning patterns of airline pilots?

DR. SARTER: Yes. In fact, there are unfortunately very few studies, but there have been to my knowledge three major studies that have looked at these scanning patterns and scanning performance. And what they basically across the board show is that one tendency that pilots tend to have is that they monitor the raw data on the airplane performance much more than they actually look at the flight mode annunciations that were mentioned earlier.

So we have done a study, for example, where we have worked with 20 747 pilots. We had them fly a 1-hour flight in a flight simulator and we introduce several events during the scenario, and one of the things that we observed was that only about 50 percent of the flight mode annunciations were actually fixated on by the pilots. So 50 percent.

And the other thing also that we noticed, and I think that is something that hasn't been mentioned enough today yet, is that it isn't only about whether they see the annunciation. So what we found, for example, was that we introduced certain transitions in the automation mode and one of the things that we saw was that especially during the late phase of descent, 10 pilots actually noticed a transition that we had introduced which was inappropriate. They noticed; they looked at it. Ten looked at it, but only 1 of those 10 pilots noticed actually that the annunciation was inappropriate.

DR. BRAMBLE: And in general studies of dual tasks or multiple tasks performance where part of the task is automated and part of it is manual, how do automation and workload tend to influence scanning, visual scanning?

DR. SARTER: So the way that we find they tend to scan is really based on expectations. And so the higher the workload, of course, the harder it is for them to in any way take in all of the information that is provided. So there's a high risk of data overload especially so much is presented in the visual domain.

But the monitoring on these flight decks tends to be not the usual standard scanning pattern, but it tends to be very much top-down expectation driven monitoring. So if the pilot expects the automation to do a certain thing, then they will look for an indication to confirm that. But if they don't expect anything to happen, then they will also not look at that indication that is associated with it.

DR. BRAMBLE: Have you studied accidents involving mode confusion errors?

DR. SARTER: I have certainly reviewed a number of the reports on different accidents and I think one of the important things to again point out, you mentioned earlier, none of this is about a particular flight deck or a particular pilot. I think what we see is there's a certain signature associated with complex system failures, and a lot of these accidents I would consider to be complex system failures. And if you go way back, to pick on one, but I'm not saying it's the only one, in 1990 I believe we had an accident that was very similar in nature in my mind. Certainly there were differences to this one, but there were a number of similarities as well.

The airplane crashed short of the runway and it was at very low speed at the time. The autothrust system was in idle open descent -- or the autopilot system was in idle open descent, and the pilots basically noticed too late what mode the automation was in and that that had led them to a problem situation with, again, low speed and being short of the runway. Another similarity as a final point on that is that the pilot, who was actually the pilot flying, was on the first of 10 flights to qualify as a pilot on this airplane. So there's a lot of similarities, I think, there.

DR. BRAMBLE: In such accidents, what factors have allowed mode confusion errors to propagate to the point where an accident actually occurs?

DR. SARTER: To be honest, it would take me an hour to answer that question because there isn't that one cause that I can give you. It usually is the combination. I think of it as there's a concept called defenses in depth, where we look at, in order to avoid these accidents, we introduce layers and layers of defenses into a system. Some might be training, some design, some procedures. And in a way, it takes all of these different things to come together for one of these accidents to happen. That's why they are so rare. But on certain days, all of these things come together, but the specific factors that lead to it vary, and that's why on the surface -- that's the risk, on the surface the accidents look different from one another, and it hides the fact that there are underlying common patterns, I think.

DR. BRAMBLE: Thank you very much.

I'd like to move the questioning on to Dr. Kathy Abbott of the FAA, and I just remind all of the witnesses to try and speak slowly for the interpreters.

Dr. Abbott, what effect do you feel flight deck automation has had on airline safety in the United States?

DR. ABBOTT: Good afternoon. Thank you for the question. Automated systems have been successfully used for many years, not just in the United States but worldwide --

CHAIRMAN HERSMAN: Dr. Abbott, can you pull the microphone closer to you?

DR. ABBOTT: Okay. And I'll try to speak up. Automated systems have been successfully used for many years worldwide, not just in the U.S., and they have contributed significantly to improvements in safety, operational efficiency and precise flight path management. However, certain aspects of pilot use of and interaction with automated systems have been found to have some vulnerability areas.

DR. BRAMBLE: Can you describe the history of the FAA and industry efforts to examine automation-related safety issues over the last 2 decades?

DR. ABBOTT: In 1996, the FAA published the Human Factors Team Report on the interfaces between flight crews and modern flight deck systems. That report looked at highly automated aircraft and it looked across different manufacturers, different operators and so on. That was an important document that had a number of recommendations that have been acted on since then.

In addition, the Air Transport Association Automation Subcommittee produced four papers on recommended practices for training and use of automated systems. Since then, there has also been an effort by the Commercial Aviation Safety Team, looking at Safety Enhancement Number 30, that was a recommended safety enhancement to look at automation and produce a report on mode awareness and automation policy for airlines.

Finally, the one that I'd like to mention is, in 2006, the FAA tasked the PARC, the Performance-Based Operations Aviation Rulemaking Committee, and the CAST, Commercial Aviation Safety Team, to create a working group called the Flight Deck Automation Working Group, to analyze operational use of and training for flight path management systems.

DR. BRAMBLE: What involvement did you have in the 1996 study on the interface between flight crews and modern flight deck systems?

DR. ABBOTT: At the time I was with NASA Langley Research Center and I was the NASA co-chair of the team that did the 1996 report.

DR. BRAMBLE: And what was the purpose of the study?

DR. ABBOTT: The purpose of the study was to look at the modern aircraft systems to find out why we were seeing accidents with aircraft that were not seeing any failures -- or not necessarily any failures, and seemed to stem from the interaction between the pilots and the aircraft systems. So the intent was to do an analysis across the different aircraft types and look at the operations.

DR. BRAMBLE: And can you give me a brief overview of the types of findings and recommendations that came out of that report?

DR. ABBOTT: Some of the findings and recommendations that came out of that report were related to pilot situation awareness with respect to automated systems and pilot management of automated systems, and we made recommendations with respect to flight desk design, regulatory improvements, pilot training and safety data collection and analysis.

DR. BRAMBLE: And what major actions were taken in the 10 years between the publication of the '96 report and the kickoff of the Flight Deck Automation Working Group by the PARC in 2006?

DR. ABBOTT: There have been a number of regulatory updates that have happened. Since then, there have been updates to 14 CFR 25.1329 on flight guidance systems, which includes autopilots, autothrottle, autothrust systems and flight directors. Also updates to 25.1322 on flight deck alerting systems, updates to Advisory Circular 2511 on electronic flight deck displays and the development of a new regulation addressing design-related pilot error, and that is 14 CFR 25.1302.

DR. BRAMBLE: Okay. Turning our attention to the Flight Deck Automation Working Group report that was a group activity that began in 2006, and the report was just released within the last month of 2013, what was your role in this group?

DR. ABBOTT: I was the FAA co-chair of that group.

DR. BRAMBLE: Okay. And in your opinion, why did it take 17 years to update the '96 report?

DR. ABBOTT: Well, regulatory activities can take quite a while. The rulemaking process is a very deliberative process that takes time to work through. So those actions were in work and implemented. In addition, there have been improvements in training, some of which were a result of the 1996 report, and it takes time for those to work through the system. So the intent was to say we've given it time for the changes to take effect; how have they affected the operational use of these systems?

DR. BRAMBLE: What organizations were represented in the

Flight Deck Automation Working Group?

DR. ABBOTT: We had airframe and avionics manufacturers. We had various operators. We had pilots, including an ALPA co-chair, who is a member of this panel. FAA representatives from Aircraft Certification, Flight Standards and Air Traffic, and we had several researchers on the group.

DR. BRAMBLE: And what was the title of the group's final product?

DR. ABBOTT: Operational Use of Flight Path Management Systems.

DR. BRAMBLE: Was this a consensus product?

DR. ABBOTT: It was concurred to by all working group members and their organizations.

DR. BRAMBLE: Did Boeing have representation on the working group?

DR. ABBOTT: Yes.

DR. BRAMBLE: Can you give us a brief overview of the findings and recommendations in terms of categories of findings and recommendations from the report?

DR. ABBOTT: Yes. The working group did extensive analysis of operational and safety data from 1996 through 2009 and identified 28 findings and 18 recommendations in the areas of flight operations, pilot training and qualification, flight deck design and data collection and analysis.

DR. BRAMBLE: What did the Flight Deck Automation

Working Group conclude about the role of pilots in maintaining the safety and effectiveness of the Civil Aviation System?

DR. ABBOTT: The working group identified that pilots contribute in a significant way to mitigating safety and operational risks in the aviation system and the aviation system is designed to depend on that mitigation.

DR. BRAMBLE: How about pilot interaction with automated systems? I understand that the group examined this issue and came up with a number of findings in this area. What vulnerabilities were identified?

DR. ABBOTT: We identified vulnerabilities in that pilots sometimes rely too much on the automated systems and may be reluctant to intervene. We saw that autoflight mode confusion errors continue to occur, and we saw FMS programming and usage errors continue to occur, as well as others.

DR. BRAMBLE: You mentioned some findings involving flight deck design as well. What challenges did the group identify in this area?

DR. ABBOTT: We identified that current flight deck designs have incorporated many safety and operational improvements with the increase of additional technologies that are available now. However, the data suggests that the highly integrated nature of current flight decks and additional add-on features and retrofits in older aircraft have increased flight crew knowledge requirements and introduced complexity that sometimes results in pilot confusion and errors in flight deck operations.

DR. BRAMBLE: Did the group identify any issues involving transfer of learning across aircraft types and different flight deck designs?

DR. ABBOTT: We did identify that it is important for pilot training and knowledge to improve that knowledge, to understand exactly what their background is. We didn't get into the specifics of moving from one type to another type.

DR. BRAMBLE: Okay. Let's talk about some of the recommendations that came out of the report. What strategies did the group recommend to improve flight crew mode awareness and reduce human automation interaction errors?

DR. ABBOTT: For the near term, the working group recommended that we emphasize and encourage improved training and operational procedures to improve mode awareness as part of an emphasis on flight path management. For the longer term, the working group recommended equipment design should emphasize reducing the number and complexity of the autoflight modes from the pilot's perspective and improve feedback to pilots.

DR. BRAMBLE: Were there any recommendations to manufacturers in terms of what they should strive for in terms of design philosophy?

DR. ABBOTT: We did not specifically get into philosophy except to say that inclusion of considerations for human center design needs to be part of the process.

DR. BRAMBLE: What shortcomings did the Flight Deck Automation Working Group find with respect to manufacturers' incorporation of human factors expertise in the flight design process?

DR. ABBOTT: We looked at that specifically in the context of what has happened since 1996, and we found that human factors expertise has been increasingly incorporated into the design process at most manufacturers but is still inconsistently applied at some manufacturers. Furthermore, human factors specialists or human factors expertise may not exist in some organizations or is called in very late in the process.

DR. BRAMBLE: And what happens when such specialists are called in late in the design process?

DR. ABBOTT: It makes it challenging to resolve those issues. It's much more difficult to address them late in the design process.

DR. BRAMBLE: You mentioned the FAA's new certification rule on design-induced pilot error, 14 CFR 25.1302. Can you describe the contents of this new rule?

DR. ABBOTT: 25.1302 is titled, Installed Systems and Equipment for Use by the Flight Crew, and that characterizes some of the scope of the regulation. It includes uniform standards that address design for flight crew error in transport category aircraft. It has four subsections. The first three describe design standards for avoiding design-related flight crew error in the flight deck design. The fourth subsection address management of errors that do occur, because of the recognition that even with well trained crews and well designed systems, errors will still occur.

DR. BRAMBLE: How will this new rule affect flight deck design and certification processes?

DR. ABBOTT: This new regulation advocates a methodical approach to the certification for design-related human performance issues. It is specifically targeted at that, and the design would be according to that certification process.

DR. BRAMBLE: Okay. Thank you very much.

I'm going to turn the questioning to Capt. McKenney.

Capt. McKenney, what role did you play in the Flight Deck Automation Working Group?

CAPT. McKENNEY: I was the ALPA co-chair of the group.

DR. BRAMBLE: What did the Flight Deck Automation Working Group conclude about the evolution of flight deck equipment and how the evolution of flight deck equipment and operations has affected pilot knowledge and skill requirements?

CAPT. McKENNEY: Can I get the Exhibit 14-E, page 40 please? And what we concluded was that pilot skills evolve over time, and the changes in the aircraft equipment and the scope of our flight operations, together with the complexity of the airspace procedures and automated tools on the flight decks, has resulted in a corresponding increase in our required skills and knowledge that the pilots need for flight path and energy management for today's complex aircraft.

We also saw that this increase in pilot knowledge and skills is not diminished as a result of the automated systems, but is actually increased, and it also requires the pilots to even be more of a pilot and also be a systems assistance manager, where we have to not only control the aircraft but also manage the additional systems that have been put on in flight deck.

DR. BRAMBLE: And what did the group find regarding the adequacy of current training time, methods and content?

CAPT. McKENNEY: Well, we found in the analysis of the 26 accidents and 20 incidents, that 40 percent of the accidents and 30 percent of the major incidents had some type of knowledge deficit of the pilots, and it wasn't that the pilots, they didn't know or weren't trained properly in some phase that affected flight path management.

And some of the things that we summarized from our interviews of the 18 different training organizations that we saw was the incomplete understanding of complex relationships and modes of flight director, autopilot, autothrottle and autothrust and flight management system computers, including such things as the systems and limitations, the operating procedures, and the need for conformation and cross verification, as well as the mode transitions and behavior.

DR. BRAMBLE: What training improvements did the group recommend to improve flight crew autoflight mode awareness and reduce human automation interaction errors?

CAPT. McKENNEY: There was a long list, but the ones that are kind of pertinent to this would be the knowledge about when to use various combinations of the automated systems, the situations that can lead to distractions, and strategies to prevent and mitigate these distractions both on the ground and in flight, knowledge related to the mode logic and maintaining awareness of the state of the system modes, task workload management, automation management, automated system mode management and decision making.

DR. BRAMBLE: I noticed in the report that there was also a finding about or a recommendation about developing or enhancing flight crew documentation training and procedures for FMS use. Can you describe that in more detail?

CAPT. McKENNEY: Okay. Repeat that question, please.

DR. BRAMBLE: There was a recommendation about developing or enhancing flight crew documentation, training and procedures for FMS use.

CAPT. McKENNEY: Okay, yes. There's been very little research that has been done in that field, and we were requesting or recommending that we look at that and so we can tell instructors, teach them how to effectively teach the mode transitions.

DR. BRAMBLE: What vulnerabilities did the Flight Deck

Automation Working Group identify in the area of pilot knowledge and skills pertaining to manual flights operations?

CAPT. McKENNEY: The first one I think is that the pilots, what we saw -- and, I mean, even what I heard this morning, is a good example, is that the pilots, you know, read and are taught the systems knowledge, but the problem is that when they go through training and how they relate that to the actual line operations and controlling the flight path management is where we're lacking in our training.

And what we're saying with the flight path management is that the way we've been effective with the training is that we train the pilots to operate the systems. We don't train the pilots well to actually how to fly the -- or maintain the flight path of the aircraft using the automated systems. So it's more than we interface with the system, but not how to actually use that, especially in unexpected situations where they may find themselves not in the pristine environment that they are trained in, in the simulator.

DR. BRAMBLE: Did the study also find vulnerabilities in pilot knowledge and skills in the areas of energy management?

CAPT. McKENNEY: Yes. Yes, they did.

DR. BRAMBLE: How about manual handling after transition from automated control?

CAPT. McKENNEY: Yes.

DR. BRAMBLE: Crew coordination, especially, about aircraft control?

CAPT. McKENNEY: Yes. The problem with the crew coordination between the aircraft control was when they're flying, we saw a lot of things. Again, this is both from the accident and incident analysis as well as the interview with the organizations, which the interviews included the instructors and the evaluators.

So the changeover, it's not necessarily who's flying the aircraft but, you know, the question is what are the automated systems doing at the time?

DR. BRAMBLE: How about the definition, development and retention of manual handling skills? Was that identified as an issue?

CAPT. McKENNEY: Yes, and that was -- it was the fact that the pilots are not given the opportunity. Sometimes with certain operators -- we have to fly by standard operating procedures, and if those procedures require us to use the highest level of automation at all times, during our normal line operations we don't get a chance to practice our manual handling operation skills.

DR. BRAMBLE: What recommendations were made by the group in the area of manual flight operations?

CAPT. McKENNEY: Let me just bring that up because it was another long list of --

DR. BRAMBLE: Well, just from your own knowledge and experience with the group, what do you recall the group concluding could be done about this issue?

CAPT. McKENNEY: For the SAFO that was distributed, we had a finding and a recommendation both on the manual handling, and a SAFO has since come out which basically says for the airline operational policy, should ensure that all pilots have the appropriate opportunities to exercise the aforementioned knowledge and skills in flight operations.

And what we were saying as we defined the flight manual operations is, it's not just the stick and rudder skills that everybody thinks it is. We also talk about the cognitive skills, the airmanship, how we fly the aircraft, how we use these automated systems to actually maintain the flight path. And so we have to think of both the psychomotor skills and the cognitive skills as part of this, and we need to train the pilots.

We spend probably more time teaching them how to fly the automated systems in the aircraft versus allowing them to practice these other skills, and I think if we look at a lot of our training programs, the amount of time spent flying approaches in manual flight operations, for example, in the simulators versus on the automation, which is what we do every day, you'll find that the automated systems is probably higher than the use of the manual handling. So we didn't give the pilots enough time to practice those skills.

And we also did a co-occurrence analysis with the manual handling skills that we looked at, and it's interesting under this point that some of the things that a co-occurred when we had manual handling operations issues, group coordination problems occurred, training was inadequate, behavior of automation was not apparent to pilots, understanding of automation was inadequate, the inadequate knowledge threat that we mentioned earlier and cross-verification errors.

DR. BRAMBLE: What lessons learned did the Flight Deck Automation Working Group identify with respect to the implementation of automation policies by airline operators?

CAPT. McKENNEY: As Nadine mentioned earlier, is if we think of our training system or the airspace air as a system, across systems, is that we put a lot of those safety layers in there, and the operator's policies and procedures and training are all part of that. And what we found was, is that when we go across the board, some of those can be confusing to the pilots and also, even today sitting in and listening this morning, is even with all of my instructor time and time flying, is I learned a few things today that I didn't know, which is quite interesting because the engineers and the way aircraft are certified and the way they're taught to the pilots and the way the pilots understand how they work for us to do their job, there's a difference.

So what makes sense, and that's probably one of the areas that we're missing, which is kind of what we anticipate in here a little bit -- or not anticipate, what we found from our analysis is that what we intend to train the pilots and how to use that in operations, sometimes does not match and the pilots see something else.

DR. BRAMBLE: So what did the group recommend? How did it recommend that airlines change their automation policies? I think in the last question you were addressing a little bit of training --

CAPT. McKENNEY: Yes.

DR. BRAMBLE: -- but also there's often a separate policy that directs pilots in terms of their general utilization of automation.

CAPT. McKENNEY: Yes. What we recommended was an operational policy for flight path management. Currently probably every operator has an automation policy that they have where the pilots tend to be part of that automation policy, where the focus is more on the automation and how to use the automation than on the flight path management itself.

So that became apparent as we looked across the system at the different factors, the accidents and incidents. And so what we are recommending is that we create an operational policy for flight path management which highlights and stresses the responsibility that the flight path management rests with the pilot and the automated systems are only tools. It's just one of the tools. You have your manual handling skills, psychomotor skills. We have our cognitive skills. We have automated systems. All of those we can use, but our primary focus should be on the flight path management and we need to flip our training around to put that focus back on.

We also found that the pilots were taught really to rely on the systems all the time, but they're not taught to, you know, question the systems. So they expect the system to work when they use it, and when it doesn't, then they get caught short.

The other one is to identify appropriate opportunities for manual flight operations. So if an operator, for example, has a policy that says we'll use the highest level at all times, then they have to make sure that somewhere within the year or every few months or whatever, that the pilots have opportunities to practice those manual handling skills, both the cognitive and the psychomotor, and that's why we labeled that manual handling operations. So we have to be sure we allow that; otherwise, you know, the skills will degrade.

DR. BRAMBLE: In 2012, Boeing published a study on airline pilot perceptions of training effectiveness. This study was conducted in cooperation with IFALPA and IATA. Did you have a role in that study?

CAPT. McKENNEY: Yes, I did. Yes. The study was conducted by Dr. Barbara Holder of Boeing, and she is a invitee to the IFALPA Human Performance Committee and she's one of our manufacturer representatives, and she was doing that on behalf of IATA and for us. So she came to our meeting, and we helped her review the questions that she had written. We represent over 100 different countries, and we have pilots from all over the world at our meeting. So we made sure that the questions were reasonable, that they could be understood by the respondents, and once we did that -- and she changed a few of the questions, I think, just to make sure, for readability -- we hosted that on our website for the pilots to be able to take the survey.

DR. BRAMBLE: Can you briefly describe the findings and conclusions?

CAPT. McKENNEY: Again, there were many, but relating to this case, the one question, they asked about the training effectiveness for automated systems, 61 percent of the surveyed pilots reported multiple encounters of difficulty completing tasks using the FMS, for example, during line operations after training, while only 25 percent of the pilots said that they were adequately prepared.

So what the study kind of showed is that a lot of the training for some of the automated systems is actually taking place during line operations and not in the actual training environment, which begs the question then if it's occurring on the line, what is actually being learned, and is it appropriate?

Another one is that 42 percent said the learning occurred on the line, and some of the areas that came out of the study that said that they could be improved was in the area of automation surprises -- and this is improved within the training before they go to line operations. They could receive extra training in automation surprises, hands-on use in operational situations, transition between modes, basic knowledge of the system and FMS programming.

And talking about monitoring and cross-verification was another issue. And for recurrent training, 99 percent of the pilots believed that monitoring and cross-verification were important skills, but only 47 percent responded that it was actually discussed during recurrent training.

DR. BRAMBLE: Thank you.

I'd like to turn the questioning now to Mr. Boyd of the FAA.

Mr. Boyd, Dr. Abbott listed off a number of regulatory changes that have occurred since the publication of the 1996 report. Can you describe for us the new rule or revised rules, 14 CFR 25.1329, and how it applied, if it applied, to the 777 during its initial certification?

MR. BOYD: Yes. The new flight guidance rule, 1329, went into effect in Amendment 25-119 in 2006. That was more than 10 years after the 777 was certified. So the new version of that rule is not in the certification basis for the 777.

That rule then, as Dr. Abbott described, updated and combined previous rules on autopilots and flight directors and added in new requirements for autothrust systems.

DR. BRAMBLE: And were there any changes to the advisory circular on flight test certification, AC 25-7, that would be related to flight deck design?

MR. BOYD: Yes. The flight test guide, AC 25-7, existed in its original release at the time of the 777 certification. There are sections in that advisory circular that address such topics as aircraft performance, braking, handling qualities, a wide range of topics that are evaluated by the test pilots during the flight test program.

At the time when the 777 was certificated in that earlier release of the document, the sections associated with review of systems, such as autopilots, had not yet been populated. They were reserved for future development.

About 3 years after the 777 was certificated, the "A" version of the advisory circular was released, and at that time, sections on autopilot systems were included in the advisory material. There was no guidance material on autothrottle systems because the guidance material is there to show compliance with the regulations and at that time there were no regulations associated with autothrottle systems.

Then most recently, after the new flight guidance rule was released in 2006, that AC was again revised to include additional guidance material for the autothrottle aspects of the new rule.

DR. BRAMBLE: Thank you.

Mr. Myers, I have about 2½, 3 minutes remaining. How have Boeing flight deck design practices evolved as a result of what has been learned about pilot system interactions since the mid 1990s?

MR. MYERS: Since the mid '90s our process has evolved somewhat. We have since even before the mid '90s, way back to the 757, 767 development, have had a human-centered design approach.

We have an organization that consists of human factors folks, of pilots and of engineers whose sole responsibility is to design the flight deck interface requirements, and that group does not have responsibility for supplier management and schedule and individual boxes and that kind of thing. So their focus is on a user-centered design.

And that group works with the rest of the company and works with outside organizations, including our customer pilots from all over the world, not just in the U.S. but all over the world, and works with ALPA and IFALPA and NASA and FAA and other regulators, and we bring in folks from universities, researchers, human factors researchers. That's all part of our formal development process whenever we do a new airplane design or a major derivative.

So that process, it has been in place for a long time. We do evolve it with each new program as the world evolves, and we try to support as best we can all of the activities that are going on in industry. The initiatives and the regulatory changes and the advisory circulars that were mentioned here at the table, Boeing has supported I think virtually all of those, and we update our product as we're able, as those regulatory changes and advisory circulars are made.

DR. BRAMBLE: Thank you very much.

Mr. LeBaron, that concludes my initial questioning. Thank you.

MR. LeBARON: Thank you.

Mr. Park.

MR. PARK: In the Exhibit 14D, page 24, please. I have a question to Prof. Sarter and Capt. McKenney. And first, can you please look at the PPT?

First of all, at 500 feet, the aircraft was at 137 knot and the PAPI light was on glide path, and the 500 feet, everything was normal. 137 knot is 5 knot higher than the reference speed. If you look at the slide, the bottom of the slide, this 500 feet is 34 seconds before the impact, and 34 seconds before the impact, the aircraft received the clearance of landing and then, according to the CBR script, there was a pilot communication. I will just read the script.

Can you please think about what kind of thing had happened 34 seconds before the impact? And, Prof. Sarter, can you please explain the human factors and the pilots' response to this action? And, Captain, can you please explain your opinion from the perspective of the captain?

Right before the 500 feet, the ACT [sic] gave the clearance of landing and an electronic voice was out like 500, and the captain said land and checklist, and then the voice of Lee Jung Min is generated from the aircraft and the captain said that landing checklist complete and clear to land, and he said on glide path, sir, and another captain said the check. And the voice message of 200 was out from the aircraft and say yes -- and the voice of yes is heard.

Can you please flip to the next page, the slide?

If you look at the yellow box, there is a quadrant time and there is a sound of beep, beep, beep, beep. It was generated 11 seconds before the impact. Thirty-five seconds before, it was 500 feet, and 11 seconds before the impact that beeping sound of beep, beep, beep, beep is generated. After that, the pilot, after heard the beeping sound, 4 seconds later, pushed the throttle to its maximum, and 3 seconds later there was a warning alert which is stick shaker activation for 2 seconds, and 2 seconds later the airspeed increased. And another 2 seconds later, the aircraft struck the ground.

I think in the sequence of this accident, the time that I explained, all this situation even, is more than 35 seconds. If you look at all the situation, Capt. McKenney, do you think under which condition the pilot is? And, Prof. Sarter, can you please explain the pilot's human factors and the response to the situation?

CHAIRMAN HERSMAN: Okay. Before you all answer, I want just want to remind you that we're not performing analysis or speculating on the cause of this accident or the actions of this crew. And so what maybe we might want to do is have Mr. Park restate his question that it might be in a more generic sense that you can talk about your experience or your studies with other crew. And so I know you all are experts in the field. We just want to be cautious about the work that's happening in this room here. It's about gathering factual information, okay?

So if you all want to take a stab at trying to kind of come up with an answer that might make sense, given those ground rules, you can do that, or I could go back to Mr. Park and ask him to rephrase. I will ask the people who have been asked the question, Capt. McKenney and Dr. Sarter, what you would like to do. Do you want to provide a response or do you want a rephrase?

DR. SARTER: I think I can provide a generic response, yes.

CHAIRMAN HERSMAN: Okay. Okay.

DR. SARTER: Who wants to start? Okay. I got myself in trouble there. Okay. I think one of the things that is being highlighted, independent of this particular case, is something that I mentioned earlier. These kinds of accidents often have a certain signature and one of the factors that tends to play a role is time constraints. So a lot of things happening in a very short period of time, and in addition to that, things happening that were not necessarily expected by the pilot.

So we mentioned earlier monitoring happens based on expectations. So we might find a pilot in some situations who does expect the automation to do certain things, which the automation does not do because there are gaps and misconceptions about how the automation works. Even when they notice that the automation doesn't do what they thought it might be doing, they might have to, under very strong time constraints, try to figure out what is going on and why things are not working the way that they expect them to work.

And in a way, all that falls under something that we refer to as disturbance management, which means that while they're trying to figure out what is going on under time constraints, we still have to basically keep the process going or keep the airplane flying, if you will.

So there is an awful lot of attention demands and cognitive demands imposed on operators at times, and they have to deal and cope with all of these demands under very high time constraints. I think that's the best generic answer I can give.

CAPT. McKENNEY: Okay, I think I'll try to do the same. So what I found both from personal experience and also from our study here is that most times when we're flying approaches, we are given unexpected situations that basically the pilots have to deal with. That's why you need a well trained and qualified pilot doing that, because we have to deal with the unexpected all the time.

Approaches never really go as planned, so we're always making changes. And during times of high workload, which that is usually as a result of those unexpected changes and during a complex arrival or with distractions, there's a myriad of tasks that we have to do as pilots, and as I was learning this morning, you may not always be staring at the primary flight displays and looking at your mode changes because you're looking out for other airplanes, you're looking at the PAPIs, you're looking at the airspeed, and you're doing so many things that at some point, you can't do everything that's required of you. So you do what I call risk management or you do those tasks that you think have a higher risk, and those other ones that are being handled, say, by automated systems or whatever, you may give control over to that, which is also what our studies showed on some of the accidents and incidents that we looked at.

So the other item, you know, during high workload like that, and time pressures are also -- because again it's a very compressed time as they said.

And the other thing that I want to talk a little bit about is, which is generic about this, is when we're trained and when we do the training, because I've done both, is if you look at 500 feet or 1,000 feet or whatever, you're looking for a stabilized approach criteria, at that moment it was there for the most part. There might have been a clue here or there, but for the pilots, if you hit all those parameters, we're trying to jump through this, you know, this goalpost, if you will; we got through the goalpost. But the question is, that wasn't good enough because if there's one thing out or you get distracted or something else is gone, and you don't catch it fast enough, even if you recognize all the alerts and warnings that we have and you respond as quickly as possible and the aircraft responds, it's not enough time.

So I think that one of the things that our study showed a little bit too, was some of the items -- and again, some of this will be my personal opinion, too -- is that when we look at stabilized approaches, we need to back up and be looking at stabilized approach from, say, 2,000 feet, 3,000 feet, 5,000 feet. In our study, some of the airlines that we talked to actually took a lot of their stabilized approaches, analyzed them, and one particular airline said almost all their stabilized approaches, they could take it all the way back to 15 to 16,000 feet and they could tell right that it was going to be an unstabilized approach just because of the changes that were made to the arrival, the way the pilots responded to them, and everything that they had to do on the way in.

MR. LeBARON: Chairman Hersman, that's all we have at this time.

CHAIRMAN HERSMAN: Thank you.

We'll move to the parties. Asiana Airlines.

CAPT. KIM: No questions. Thank you, Madam Chairman.

CHAIRMAN HERSMAN: Thank you.

Asiana Pilots Union.

CAPT. MIN: Yes, Madam Chairman.

Capt. McKenney, are you familiar with the approach to Runway 28-Left at San Francisco?

CAPT. McKENNEY: Yes, I am.

CAPT. MIN: If so, could you compare the external distraction on visual approach compared to external distraction during a visual approach at most other airports?

CAPT. McKENNEY: It's --

CHAIRMAN HERSMAN: Capt. McKenney, could you repeat the question for everyone to make sure that we all heard it?

CAPT. McKENNEY: I think -- well, what I was going to answer, I hope it's correct, is he wanted me to talk about the approaches at 28-Left compared to other approaches, I think. Is that correct?

CAPT. MIN: Visual approach.

CAPT. McKENNEY: Oh, visual approach.

CHAIRMAN HERSMAN: Visual approach.

CAPT. McKENNEY: Visual approach. Okay. Yeah, coming into San Francisco, the visual approaches there, depending if it's 28-Right or 28-Left, they're basically simultaneous, what we call simultaneous ILS approaches. Between the runways, I think it's 5-, 600 feet. It's very narrow compared to most airports. So we basically come in from two different angles. And so as we're coming in, if you're coming in from, for example, 28-Left, you're clearing for the people that are coming into 28-Right. 28-Left is coming in from over the water, from over the ocean. 28-Right is coming from over the mountains from the east.

And so when we're coming in, air traffic control is trying to sequence us in and what they normally do is they put, you know, the regional in front of the big heavies, just so they don't get it the opposite way for weight turbulence. But a lot of time is spent, and it's distracting to us trying to -- instead of flying the approach, that you're actually trying to find the other airplanes. So it distracts the coordination between the crew because we're trying to find that a lot of times.

Again, if it's the middle of the night, and there's nobody there, that's fine, but normally it's there. The 28-Right airplanes are coming in on an angle and they actually have an offset arrival, that they come in, inside the bridge, inside 1800 feet, and then they sidestep to the left to line up with 28-Right. So it's kind of a very complicated one and they're always in -- we're usually high and fast because they can't let us down or intercept until they make sure that we have the other aircraft in sight, and with the weather conditions sometimes, again it depends, but a lot of times, it's hard to pick up that other aircraft until you get pretty much over the San Francisco Bay.

CHAIRMAN HERSMAN: But the conditions on this day were clear weather visual conditions, correct? What you're talking about is another -- you know, other experience that you might have had?

CAPT. McKENNEY: Yeah, I was just answering it generically.

CHAIRMAN HERSMAN: Okay.

CAPT. McKENNEY: So I wasn't responding to this one.

CHAIRMAN HERSMAN: Okay. I just want to make sure there's not confusion about what we're referencing.

CAPT. McKENNEY: But in response to that, even in a visual, it's hard sometimes with the moisture and the mountains and the haze. Again, I don't know what the weather was that day because I wasn't there, but -- I'll just leave it there.

CHAIRMAN HERSMAN: Okay. Great.

CAPT. MIN: Could this higher level of external distraction have an impact on the flight crew's use of automation during the approach?

CAPT. McKENNEY: Okay. Repeat that.

CAPT. MIN: Could this higher level of external distraction have an impact on the flight crew's use of automation during the approach?

CAPT. McKENNEY: Yes, it can.

CHAIRMAN HERSMAN: Again, we want to not speculate about this accident crew and the circumstances in this situation. So again the questions, if the people asking questions can try to help the panelists, and the panelists can avoid focusing on this accident when you're answering.

CAPT. McKENNEY: So if I answer the question, can distractions -- because I think the question is can distractions --

CAPT. MIN: Okay. I'll give you the next question.

CAPT. McKENNEY: Okay.

CAPT. MIN: Capt. McKenney, when the captain is doing training, what is the priority of his responsibility, PIC, PM, instructor pilot?

CAPT. McKENNEY: Okay. The priorities of the instructor pilot -- so it's the instructor pilot, pilot monitoring or flying, okay. They actually have to do all of them at the same time, but for the instructor pilot, it should normally be that they're making sure that the aircraft is safe and doing the pilot monitoring skill at the same time. So they should be making sure that the flight path management is safe at all times.

CAPT. MIN: What do you believe can be done to get pilot to go around when the approach is unstable?

CAPT. McKENNEY: Okay. Repeat it once more.

CAPT. MIN: Okay. What do you believe can be done to get pilot to go around when the approach is unstable?

CAPT. MIN: So if I understand you correctly, is what should be done to get the pilot to go around. So with go-arounds, in general, I think it should be -- if I'm answering the question correctly, either pilot should be able to call a go-around at any time that -- and any pilot, even a relief pilot, because I flew in an augmented aircraft for 20-some years. Any pilot should be able to call for a go-around if they see it's unsafe, and obviously the pilot in command has the ultimate say-so if it's not, but the pilot flying, if they hear go around, they should immediately execute a go-around, and or if they see they're going around, if they don't like the situation, they should immediately do a go-around.

CAPT. MIN: Okay.

CAPT. McKENNEY: Does that answer your question?

CAPT. MIN: My final question, Dr. Sarter, can you compare the use of autothrottle in a Boeing 777 with the use of cruise control in an automobile? How often do you expect an operator to monitor their speed when the machine always maintain the speed correctly?

DR. SARTER: Okay. So I guess you are trying to get at overreliance and what some people might call complacency.

I guess you could compare the use of a system like the autothrottle to a large number of different automated systems, and if an operator makes a large of number of experiences with that system, where the system operates reliably, then yes, we do see a tendency to rely on that system which, in a way, is the same response, if you will, to that experience.

We also see that this actually changes quite a bit over time in that -- in the case of pilots, we have looked at how that reliance develops over time and usually based on the way that they're being trained and things are being explained to them, they may be overrelying for some time, but they make experiences with the system that calibrate their trust in the automation over time. And so usually with increasing experience, their trust in the system and their reliance on the system becomes more calibrated.

I think one big difference I would point out though is, again, if you compare it to cruise control on a car, there's lots of differences in my mind. One of them is that there is not the plethora of systems that we have on the modern flight deck. So in other words, if I turn on my cruise control, there are not lots of other things that I have to monitor at the same time in terms of systems.

At the same time, fortunately in this case, or not, at the same time, you have a difference in terms of the operators. So a driver of an automobile will have a basic knowledge of what the cruise control does but has not really been trained very thoroughly on that system. So I think there are some differences that need to be pointed out as well.

But I think in general we see when you provide automated assistance, and the assistance is fortunately highly reliable, then over time, people might develop certain reliance on that system.

CAPT. MIN: Okay. Thanks, Madam Chairman.

CHAIRMAN HERSMAN: Thank you.

Air Cruisers.

MR. O'DONNELL: Madam Chairman, we have no questions. Thank you.

CHAIRMAN HERSMAN: Thank you.

Boeing.

MS. BERNSON: Thank you, Madam Chairman.

Mr. Myers, how does the Boeing flight deck design as implemented in the 777 provide cues, annunciations and other information to minimize confusion?

MR. MYERS: We design the flight deck, per one of our top level philosophies is that we design the systems to be error tolerant and we apply automation to aid and not replace the pilot. What that leads us to in terms of design is that we're looking for, in the area of -- I'll just talk about the error management.

In the area of error management, we have to make some design assumptions about the pilots and about the automation and about the cruise monitoring skills. So if we ask a pilot to watch the paint dry, we don't expect to get the same level of monitoring engagement as we would if we asked them to, say, watch an Olympics speed skating event. We think that they would be much more engaged in the latter.

The same applies to the flight deck design. We expect that the cues we provide are available to the crew and that they will use those cues to the extent available. If they get behind the airplane or if there's an automation surprise, we expect them to back off on the level of automation as required and revert to more basic skills, either by flying off just the basic modes of the autopilot, for example, or going purely to manual flight. And we expect them ultimately, if the airplane is not doing what they expect it to do, that they can disconnect the automation altogether and fly manually.

But regardless of what level of automation they're in, depending on the phase of flight, we'll expect the crews to monitor the fundamental course, path and airspeed of the airplane. That's always what we expect them to go back to, and at the end, if they monitor those three things, and if they don't like the way the approach is going, they execute a go-around and the intent of our design is made.

MS. BERNSON: Thank you very much, Mr. Myers. We have no further questions.

CHAIRMAN HERSMAN: Thank you.

City and County of San Francisco.

MR. McCOY: Madam Chairperson, I'd just like to clarify that the spacing between the two runways at San Francisco is 750 feet apart just for the record. And I have no further questions.

CHAIRMAN HERSMAN: Thank you for that clarification.

FAA.

MR. DRAKE: Madam Chairman, FAA has no questions.

CHAIRMAN HERSMAN: Thank you.

Member Sumwalt.

MEMBER SUMWALT: Yes. Mr. Myers, we were just talking about monitoring, you were, and earlier this morning you said, and I wrote down what you said. It's not an exact quote, but I believe you said we assume our crews are very good at monitoring. And what data did you use to support that assumption?

MR. MYERS: We've used the data that we've gained in designing the systems and flying thousands of hours in the simulator and observing the pilots that we bring in from all over the world to fly the simulators. We're also getting the data from the flight tests that we fly. We fly thousands of hours of flight tests on all of our airplane programs, and we have engineering representatives on all those flights. We review the data, and from that we've found that response times for pilots are very low -- I mean they're good, with critical phases of flight and we can rely on them being engaged in those critical phases of flight.

MEMBER SUMWALT: Thank you. I realize the 777 was certified back in the '90s, but are you aware of a study that Boeing's Randy Mumaw -- and I think, Dr. Sarter, were you involved in that automation study, and I think that's what you were referring to earlier -- that it mentioned that flight crews, a lot of mode annunciations are missed and, Nadine, I think you said about 50 percent of the mode annunciations were found to be missed in that study. Is that correct?

DR. SARTER: So what I was saying that about 50 percent of them across the board, and you need to differentiate a little because we were looking at, was this a mode transition that occurred as a result of directed preceding pilot input or was it a mode transition that occurred with some delay because of some coupling or something of that sort. The numbers differ a little bit but across the board about 50 percent of the ones that occurred were fixated.

MEMBER SUMWALT: Thank you.

So anyway, Mr. Myers, are you familiar with that report?

MR. MYERS: Yes, I am.

MEMBER SUMWALT: Now, Dr. Abbott, I'd like to turn to you. You've been studying automation for a pretty good while. I'm going to suspect that the '96 report was actually commissioned at the end of '94, I believe, and then so you were involved in that and then, of course, this one here that started in '06, and so over 17 years or so, plus prior to that. You've studied dozens of aircraft accidents involving automation, hundreds of incident reports and literally thousands of reports from LOSA data involving normal operations. So what is your opinion of how well pilots are at monitoring highly reliable, highly automated systems?

DR. ABBOTT: I'll refer specifically to the date from the Flight Deck Automation Working Group report, and we looked at two categories. One was general monitoring for which we did not have the LOSA data, so therefore, we can't speak to the normal operations, at least from those data. But the accidents that we reviewed, approximately just under 40 percent of those accidents had a monitoring error of some kind involved in them. So those were the accidents that were reviewed by this group.

A subcategory, it's not completely a subcategory, but cross-verification errors are related types of errors, and we saw in the LOSA data, 25 percent of the flights had a cross-verification error of some kind.

MEMBER SUMWALT: That's very interesting. So about 40 percent of the accidents you looked at and 25 percent of the LOSA data you looked at involved a monitoring error of automation.

DR. ABBOTT: The first number, just under 40 percent was monitoring in general. The 25 percent of the LOSA errors were specifically cross-verification of inputs to automated systems.

MEMBER SUMWALT: I'm sorry. The very last part of that was?

DR. ABBOTT: It was specifically cross-verification of inputs to automated systems.

MEMBER SUMWALT: Thank you.

Mr. Myers, is that consistent with your data for monitoring?

MR. MYERS: We don't have our data in that form, so I can't say that I have comparative data. But we do understand that there are errors in monitoring things such as flight mode annunciations, but like I said, what we expect, then, is that if the crews are at all confused, that they have the capability to rapidly and easily exit the confusing mode and reduce to a level of automation that they're comfortable with.

MEMBER SUMWALT: Would you agree that in order to detect that they're confused, they have to monitor and that's how they detect is through adequate monitoring?

MR. MYERS: They have to monitor but they don't necessarily have to monitor the modes. We hope they have the bandwidth, the workload is such that they're able to monitor all the modes, but if they are simply monitoring course, path and airspeed, and if they don't like what they're seeing, they revert to lower levels of automation, including manual flight, then the problem can be solved at least from a safety standpoint.

MEMBER SUMWALT: Thank you. I'd like to ask that for the record you submit any data that Boeing may have used in the assumption, like you said this morning, that we assume that pilots are very good at monitoring. Any data that you may have to support that, we'd like to have please. Thank you.

CHAIRMAN HERSMAN: Member Weener.

MEMBER WEENER: I find the discussion about monitoring to be very interesting. There's really a couple of monitoring tasks going on in this particular situation. There's one task of monitoring another pilot, and then a lot of the discussion so far has been monitoring systems. And the point's been brought out that there's a hazard with automation that works right almost all the time because you get surprised when it doesn't work properly.

And I think I'll address this to Dr. Sarter. Could you just make a few comments about what you see as the difference between somebody performing a manual task and somebody monitoring that manual task?

DR. SARTER: You mean monitoring the task being performed by an automated system?

MEMBER WEENER: Well, in both cases.

DR. SARTER: Okay.

MEMBER WEENER: Monitoring another person doing that task and then monitoring that task being done by an automatic system.

DR. SARTER: So clearly if you are -- that we do supervisory control, you have certain amounts of attention resources that are being freed up because you are not necessarily performing the task yourself. At the same time that could actually create difficulties for you because you are not necessarily getting the same direct feedback, for example, that the person might get performing the task themselves.

You probably also take a longer term, higher level perspective as you monitor as opposed to performing the task yourself. So I think your rule changes and the resources you have available for monitoring changes significantly between the two of them.

And I do not know whether you are referring in this case to the check airman versus the pilot. I assume that is what you're saying. The person in the right seat monitoring the pilot flying.

MEMBER WEENER: Yeah, I was looking at it in both cases, monitoring an automated system performing a task and then monitoring a human performing that task.

DR. SARTER: So if I compare those two, I think the big difference is -- and that has, I think, been shown in several incidents and accidents to be a problem. If I'm a pilot and I monitor another pilot, I think I have a very good understanding of what I can expect from the other pilot because the pilot has gone through the same training, more likely than not, the pilot will have the same idea of what our goals are, what our next steps are, how we're going to perform this task. So I think my view of the work and my expectations very much overlap with this other human being, and I have certain things I can rely on. So I know that they know certain regulations in aviation, for example.

If I monitor an automated system on the other hand, that system wasn't built by myself. It may have been built in ways that it performs tasks in ways that are different from myself. And so, we've seen sometimes pilots monitor a system that worked perfectly reliably, but it worked in a way that the engineer had thought of the task and so the pilot tries to monitor what the automation is doing and is in a way surprised because the automation does it different from how they would have done it.

So I think you're suddenly monitoring some agent, if I want to call it that, that hasn't gone through the same training, that hasn't necessarily been programmed to perform a task the same way, and I think that can make it more difficult to understand what the system is doing and what its next steps will be.

MEMBER WEENER: But if the automated system had been familiar to the point where the monitoring individual was familiar with what it was going to do, so then he or she would have a presumption of what the system was going to do and is there then a parallel that the monitoring instructor has a presumption of what the monitored pilot is going to do?

DR. SARTER: Yes. So if you assume that the pilot has the perfect, complete, accurate mental model of the system, then you could say, yes, he can make the same predictions, the same expectations, and that's the monitoring strategy I mentioned earlier. It's really top-down monitoring is what's happening. It's driven by expectations.

If the expectation is to be violated, then you would basically need what we call bottom-up monitoring where some cue in your environment notifies you of the fact that what you're expecting may not be happening or something has been violated already. So now you need to be driven by data and your environment rather than by expectations that you have.

But, yes, if anybody ever had the perfect, complete, accurate mental model of the automation, then barring one thing, which is that you simply at some point may overwhelm the person with data in a short period of time, outside of that situation, I would expect them to be able to predict just as well what the automation would do as they could predict what a human would do.

MEMBER WEENER: Very good. Thank you.

CHAIRMAN HERSMAN: Member Rosekind.

MEMBER ROSEKIND: So I'm going to start with Dr. Sarter and Dr. Abbott, but we're going to extend the same question to others. The question's going to be longer than your answer because what I'd like really is a number and up to three on a list.

There's been a lot of discussion about philosophy, and I think it's always interesting to see how much philosophy data, et cetera, area actually reflected in manufacturing the cockpit design and the actual operations training. So I'm curious, starting with you two, how much do you think automation philosophy, human factors, design, et cetera, is actually reflected in the current state of cockpit design and training operations? If you think it's 100 percent coupled, that's 100 percent.

And then the second part of the question is where are the gaps? I'm not asking for a reiteration of the report that just came out. This is one of those times you can give your own opinion and speculate and you're okay.

So just starting with the two of you, from a scientific standpoint, where do you think we are as far as the penetration of everything we know, data, philosophy, et cetera, and actual status of what's going on now? And if you think there's a gap, identify like up to three. Dr. Abbott, you want to start?

DR. ABBOTT: I can't give you a specific number. You've asked a very broad question across a variety of the airplanes that are out there and a variety of manufacturers and that sort of thing. I think there's been significant integration of the philosophies and policies of human-centered design into airplane flight decks that has increased over the last 15 years. So we've seen significant improvements and a lot more attention to those topics.

I think one of the important gaps that I would say sometimes does happen is a difference between the philosophy and the design and the way that the systems are actually operated. So I would leave it at that.

MEMBER ROSEKIND: Great. Dr. Sarter.

DR. SARTER: I'm glad Kathy started. I'm going to refuse to give a number as well, I think.

MEMBER ROSEKIND: Well, if you want, I can put the pressure on a little more, because I'm not looking to the Ph.D.'s to say the data suggests. I'm trying to, you know -- that's the idea, is to look at broadly across, you know, the experience that you have and just get a feel. Are we, you know, 90, 100 percent there or, you know, are we still in its infancy? We talk about this, but it's actual reflection in operations training is really, you know, where are we with that?

DR. SARTER: Well, I can tell you that we're at neither extreme, I think. That's a safe bet.

I think some of the gaps that maybe I see, and I agree completely with what Kathy said. I think a lot of improvement has been made. I think it's also important to point out, given how everybody's kind of looking at everybody else, that everybody involved in this has the best of intentions. So everybody's trying to implement things the best way they can given what we know. And to me, the last part of what I just said is going to be critical, given what we know.

My impression is that there have been proposals, for example, for how training might be changed, how exploratory training may be more important to do in the way that a pilot in the simulator should have the opportunity to experience situations that we have never experienced before and sort of play in a supervised fashion with the system. That's the proposal that's out there, and I think maybe some airlines may have adopted some of it as well already. But then I turn around and say, what are the empirical data that we actually have to show that this will actually work?

The same is true, I think -- we talked about monitoring or not. If we want to improve the way that pilots monitor, don't we first need data on how they monitor currently and to what extent that monitoring strategy is actually even associated with performance, because right now we're often just looking at the process of monitoring but we can't necessarily show that one way of monitoring leads to better or worse performance than another way. So to me, I guess being the scientist, I would say there is data missing. I think everybody is trying the best they can as they propose solutions to problems, but we don't run enough studies to show whether something is indeed effective or not.

MEMBER ROSEKIND: Great.

And, Capt. McKenney, I'm going to let you wrap this one. I just want to acknowledge a very thoughtful comment earlier, and so I'm kind of looking to you because you've had experience flying the airplane, being on these committees to sort of look at the design part of it and the training side. So, you know, how much do you think all this stuff you've learned about has really penetrated these areas and where would the gaps be?

CAPT. McKENNEY: Okay, I'll give you a number or at least a guess, but just my personal opinion, but it's definitely greater than 50 percent but -- it's probably, you know, 70 or a little bit higher, but, I mean, all the training programs, we're trying the hardest we can. We're doing what we know. I think there's a lot of -- you know, I can tell you a lot of the gaps.

There's a lot of research that hasn't been done. I believe a lot of the training, from what I see, is a lot of the training is done as it was done 30, 40 years ago. We've got these new automated systems, we're trying to do it, but we're using old training techniques, old delivery systems. So we need methods of instruction, we need new devices to do the training and we need instructor training to teach the instructors, train the trainer how to actually teach this to the pilots, because right now a lot of them are given the material, so we give them all this great material to do, but they don't know how to teach it, if that makes, you know, if that makes sense to you.

So we train the successes. We train how the automated systems work well, but we don't train the exceptions. We're in the simulator a lot of times, and we do the pristine sim where we do it time over time, the exact same scenario, so the pilot understands, that they learn it and then we check them on that, and they're good to go to the line.

But what we didn't train them on, it's what we didn't do, is we didn't give them all the different surprises that we've seen or that shows up from our safety data or our personal experience. We could do that very easily.

An example, you know, and again high and fast on final. I just went through training a couple of years ago and I went out on my OE myself and the first time that I -- when I arrived, you know, they gave me 180 at the marker because I had been off for a year, I hadn't flown, and they brought me in high and fast. I was like, I never saw -- I just realized, I says, I just spent, you know, over a month in training. I never saw that once in training, and yet the first, you know, leg of my OE, is here I am going, oh, my gosh, and I was behind the aircraft, because I was not prepared. And I was upset because I knew better, and I didn't, you know, understand that. So the pristine world that we live in, in the simulator, we need to be training all the exceptions as much as we know.

The other question is how do we measure success? We need to really address that, and what I mean by that is right now I see a lot of training to exposure. We expose a pilot to something, and we say they're trained. We assume that they understand it. But going back to what I just said, if in that simulator I give them two or three scenarios that are realistic from what I would get on the line, and then I see if they really understood the knowledge and skills that I taught them, did they really get it, because that's the only true test, not just show them once and assume that they got it.

The assumption of skills. A lot of our training programs, and I heard that word this morning several times, we assume that the pilot has skills, but how do we know they have them? And the key there would be that again we evaluate that somehow. And so we have to figure out how we do that.

And finally with the difference in the automation policies is, in our paper -- in our study, there's a lot of confusion with automation policies and what we do, and the biggest thing I think that was an eye opener for me when we went through the studies and we saw a couple of air carriers doing it, is the separation of guidance and control when we're talking about automated systems.

Some of the automated systems the pilots use for control, such as the autopilot and the autothrottles. A lot of the other stuff is for guidance, but yet we group that all together in a linear fashion and usually say, hey, all the autopilot -- you know, all the automation off or all on. So we need to be training a whole different thing, and then training our instructors.

And one of the things that we said when we interviewed all the instructors, almost across the board, every group said that they wanted more training in how the automated systems worked and how to train those and actually evaluate them, is what I'm talking about, how to evaluate those. So we need more research in that area. So, does that help?

MEMBER ROSEKIND: And I'm just going to -- you brought something up I've been trying to emphasize, and it will do it rather quickly, and that is you talked about successes. Because earlier, Mr. Boyd, one of your comments had to do with, just because it meets the regulation compliance, it doesn't mean its safe. And it's been one of the problems. We talk about hitting the standard and the criteria, doesn't mean it's effective, and that's what you're talking about in the operations, how much the data's translated and in the training, and I think, you know, we've got to get away from just compliance being different from whether or not your operation, training, et cetera, is actually effective for the outcome that you're seeking, and I'm not sure we always talk in those terms. Thank you.

CHAIRMAN HERSMAN: Vice Chairman.

VICE CHAIRMAN HART: Thank you. I'd like to start with kudos to the industry for the series of automation reports they've done, for doing it on their own in a collaborative way and trying to tackle this challenge, and kudos for doing that because I think that's very exciting.

I'm going to ask a couple of questions that -- I don't know whether this report deals with it or are there any other reports, but I guess, Dr. Abbott and Capt. McKenney, does this latest report or do any of you know of any studies that are granular enough to say this series of accidents and incidents had excellent CRM and this series of accidents and incidents didn't have excellent CRM, and is there any intersection between good and bad CRM versus effective use of automation? Does that question make sense?

CAPT. McKENNEY: To answer the first part of the question, I would say that, no, I don't know of any studies that really look at how CRM does compared, you know, to the accidents, what's good and what's bad. One of my jobs at IFALPA, CRM falls under my area of responsibility as a human factors chairman for IFALPA.

But what I can say is that, again, another one of the exceptions or what we're not training is we train CRM and then we assume that the pilots can transfer that to their flight operations. And as an industry, I think we can make heavy strides in the safety industry if we figure out a way to integrate the CRM skills, decision making, crew coordination, communication, all those things, while we're doing the maneuvers, while we're training them the operational maneuvers that they're going to be doing in a realistic environment.

Because then we train in the basic knowledge of the CRM, and a lot of us -- you know, again, a lot of the training programs cover it, but they don't cover it in depth and they expect that the pilots can make the transfer. And so if we could start figuring out a way to integrate that with the training, where we're not just training, for example, an ILS approach, but all those other factors with it, that's one of the keys. I think that's one of the areas that our report actually helped us find that we're missing.

DR. ABBOTT: I don't have anything to add to Capt. McKenney's comments.

VICE CHAIRMAN HART: Thank you. Then a related question is, again, does either this study or any other study that you know of, you're looking at how to make automation more effective, but do you go to the point where, oops, it was not quite effective and so you have to do some sort of alerting, and the question is, are there any studies that looked to the effectiveness of aural alerting versus visual alerting and bringing back that monitoring that was apparently absent enough to trigger the alert?

DR. ABBOTT: I'll speak to the update in the standards for flight crew alerting that have been recently instituted, and it wasn't a question of visual versus aural. One of the requirements in that new regulation or rather the updated regulation, 25.1322, is to have dual senses for an alert to ensure the attention getting aspects of it. So that you could have both visual and aural or visual and tactile, for example, depending on the design itself.

CAPT. McKENNEY: Let me just add to that. One of the biggest things I think of our report, of the Flight Deck Automation Working Group, was that we looked across the system and looking for a system solution, not a point solution. And in my experience as an accident investigator in the safety world is that a lot of the solutions to many of the accidents and incidents is that they look at the point solution and they say, okay, we'll just fix this and they don't see what the repercussions are. And a lot of people hear me, you know -- is that all you do sometimes is just move the workload, move the task. So you solve one problem but you just move it somewhere else.

And so my hope is that we look at, you know, this incident, accident, across the system to find out a system solution, which is what our report was trying to do, so we can attack all those issues to make it a safer world. Thank you.

VICE CHAIRMAN HART: Thank you. And one more question is, you mentioned that this report has 18 recommendations. Who are these recommendations made to and what's the prognosis that anything will happen on those recommendations? I assume some of them are regulatory recommendations to the FAA, but some of them are probably to various aspects of industry. What's your prognosis that anything will happen? What are the next steps to make sure anything happens?

DR. ABBOTT: The good news is that there's already a lot of work that's going on to start implementing those recommendations. So none of the recommendations required new rulemaking. Some of them do recommend new guidance material based on existing regulations.

In addition, there are a couple of forums for allowing industry and FAA to work together on voluntary aspects of doing recommended practices and making improvements. The Commercial Aviation Safety Team is a great example of that. There are others as well.

VICE CHAIRMAN HART: Well, thank you, and again kudos for taking on the challenge.

CHAIRMAN HERSMAN: Dr. Abbott, you worked on both the '96 study and the study that was released this year. Can you give me a sense of whether we've seen a delta or a change between the manual versus reliance on automation when flying large transport category aircraft in those years?

DR. ABBOTT: That's a hard question to answer because back in the '96 report, we did not have the data available to provide a baseline. We had insights based on interviews and voluntary pilot reports.

One of the things that we did identify in the report that just was released, the Flight Deck Automation Working Group report, is increasing use of the automated systems especially to reflect the changes in airspace operations that involve more use of the flight management systems and so on.

CHAIRMAN HERSMAN: And just in general, because we're talking about some of the challenges related to automation, but there are also some positive things with respect to automation. Do you believe that automation has made aviation safer?

DR. ABBOTT: Yes.

CHAIRMAN HERSMAN: Okay. I am looking at the appendix on your study, and it actually has information about some LOSA observations, and it talks about the number of automation errors that occurred in different phases of flight, and actually one of the highest phases of flight where they have automation errors is descent arrival and landing. And there is a little bit more specificity when you talk about some of the poorer marginal automation management ratings there, and in particular, it talks about vertical mode confusion. Vertical mode confusion, speed, energy issues and/or lateral vertical deviations were all coded against about 40 percent of consequential outcomes, and this is specific to descent approach and landing.

And so I want to go back to something that Dr. Sarter raised earlier when Dr. Bramble asked her one of the first questions out of the box, is what are the big challenges with automation, and mode confusion was one of the things that you referred to. And so let's talk about how we actually create better mode awareness. What are some of the specific steps that you would recommend be taken to understand the mode that they're in and not to be confused about what it might be able to do for them?

DR. SARTER: So I think you really have this two-step process going on. That's why I mentioned earlier, it's one thing to get them to notice the change and then it's another one to actually get them to understand it.

So I think the first task we have is to ensure that their attention is indeed being grabbed by that transition, and I think that can happen various ways, and we talked just a few minutes ago about different areas, visual, auditory and we might add tactile alerts to that. There was quite a bit of work on that during the '90s basically.

CHAIRMAN HERSMAN: So maybe I can slow you down right there, because I know you understand all of these things, but maybe we're not all keeping up with the speed of your conversation --

DR. SARTER: I'm sorry.

CHAIRMAN HERSMAN: -- but maybe we also don't understand it.

DR. SARTER: Yes.

CHAIRMAN HERSMAN: So when you talk about the improvements that can be made that are visual, explain specifically what you're talking about. Are you talking about things that the aircraft would do, like alerts that would come from the aircraft, or are you talking about callouts that would come from the crew? So elaborate on that a bit.

DR. SARTER: So I was talking in this case about feedback that would come from the airplane, that would be displayed on something like a PFD and the FMAs, for example. And the work that I was referring to was basically looking at what should the nature be of these indications of these alerts to the fact that there was a mode transition.

And there have been experiments looking at in what modality should it be presented. For example, currently we talked about the little green box earlier that stays there for 10 seconds. So a lot of the feedback is visual in nature, and when we look at modern flight decks, there is an awful lot of visual information being presented. So there is this risk of visual data overload. And so people have talked about maybe we should move that information to other channels, and I think that's in part where the callout idea comes from, so it's an auditory thing, no longer a visual thing.

It could be that you use the sense of touch. That's why

I mentioned tactile information presentation, because we know that pilots tend to complain about visual overload on flight decks but also to an extent they complain about auditory clutter on flight decks. So there is an awful lot of auditory information presentation as well.

And so that is what actually triggered the use of other sensory channels like the sense of touch. And we use that for some things like the stick shaker, for example, right. So that would be one step in the direction of trying to make sure that pilots, no matter what task they're engaged, and most of them are visual in nature, that they are still capable of noticing that there was a transition.

But then the next step would be to say you may look at it, and as I mentioned from this other study earlier, a lot of them, in this case, 9 out of 10, looked at the transition. We know that from eye tracking data. And yet they never said anything or did anything about it. And when asked about it later, it became clear that they saw it but they didn't understand that that wasn't the mode they should be in or what that mode actually meant.

So I think that's more a mental model issue and the mental model part probably evolves through two different channels. One would be training, and that is the exploratory training I mentioned a moment ago where I said maybe if they had a chance to actively work with the system through exceptional cases like Dave

McKenney was saying, that helps them build this model actively. Rather than just being taught the model, they build the model, and I think that could be more effective.

And the other way, of course, is through line experience where they actually experience these situations, and as a result of that, they update their model of how the automation works, which in turn helps them build expectations which in turn helps them monitor.

So I think the two really need to go hand-in-hand. It's the design and the training to get the observability and the mental model in place.

CHAIRMAN HERSMAN: So you think it's like that old game of telephone or operator where you have a situation where it starts with the designer and what does the designer know? What do they understand about the system that they've created? And then it moves to the manufacturing process and the materials that the manufacturer might possess or prepare or provide to people about what the designers were expecting the aircraft to do.

And then you've got potentially the operator and the materials that they may produce, which may be different or they may be the same, and then you've got trainers who may be separate from the operator, and then at the end, you've got the pilots. And so it's kind of a long path to get from the designer to the actual pilot who needs that information and understanding how that works.

I think we've built that with Panel 1, talking about the design and the certification, and Panel 2 about some of the operations issues and the training issues, and here we're talking about some of what you're seeing with respect to line pilots and experience in the real world and some of the challenges.

I do want to conclude with the issue with respect to the mode confusion or the mode awareness. Do we have any empirical data, research data that you can share with us, and you can provide this for the record later, that would tell us again what specific steps you want to take? I'm not a pilot. I don't know, but when I -- I know that we've had a lot of concerns in the past about altitude deviations or, you know, kind of violations there, that's a significant issue, it's important.

When I watch crews in the cockpit, I'm just in the jump seat. Again, I'm not a pilot but I watch them. They get the information, they read it back. If there's a problem, they hear it. They talk about it. They dial it in. They point to it. They repeat it. I mean, there is a lot of communication about that. That's important. They don't want to get that wrong, and they have a good communication about it.

When we have a situation where we have a pilot in command who doesn't really understand what mode they're in, not aware of what mode a crew might be in, and you have a crew member who doesn't even understand, even though they may be involved in the cockpit what mode they're in, I mean, that's a real issue of confusion. It's not just understanding what the mode does, but not even understanding if you're in a particular mode. How do we get to a point where if we know mode confusion or mode awareness is an issue, how do we get to a point where we don't have that same kind of confusion? Because it's not just in this accident where we're raising this issue. It's over and over again.

DR. SARTER: Yes. Number one, yes, I'm more than happy to share everything that I can in terms of empirical data on this issue. And number two, I want to mention one thing. So we talk about the design and we talk about the design of the flight mode annunciations, and then the training for monitoring them.

I think one thing that has not been discussed very much -- I briefly mentioned earlier that pilots, in the study that we ran, they did not look at the flight mode annunciations very much, but what they did monitor more closely was the actual airplane behavior. And I think that is an important link as well, and I think there have certainly been efforts and successful efforts there in that arena.

For example, in the '90s, one of the big issues everybody talked about was that pilots had a hard time understanding VNAV modes, vertical navigation modes. One of the problems I think at the time was that all they would have on the flight decks at the time was a top-down view of their flight path, but they did not have a side view of their flight path. So basically they had the lateral information but not the vertical information, and that triggered a lot of development and introduction to flight decks of vertical situation displays. So now I do not just look at something and it says VNAV path or VNAV speed, and I in my mind have to figure out what that means for the flight path, but I have a side view of the actual airplane path which shows me where am I going to go next and what is the airplane going to do; is it going to level off or not?

So I think it's the old principle Don Norman used to say, put knowledge in the word not in the head, and that's what that does. It puts the knowledge in the word in a display in front of the pilot, and for the pilot, that's data that they're used to dealing with, to look at a flight path, for example, rather than looking at VNAV speed and trying to figure out what might that mean. So I'm not saying we get rid of the VNAV speed, but I'm saying we also provide a visualization of what that implies.

CHAIRMAN HERSMAN: Great. Thanks. You've given us a lot to think about.

Additional questions? Member Sumwalt.

MEMBER SUMWALT: Thanks. I'll make just a quick follow-up but first a point of privilege. Dr. Abbott, I want to thank you and congratulate you for your efforts on this. I know you led the '96 report, co-chaired that one. You co-chaired, along with Capt. McKenney, in this recent report. These reports, both of them are in the docket under Section 14 if anybody wants them, but

I know it was a group effort, but thank you for your leadership there.

Dr. Abbott and to Dr. Sarter, I flew an Airbus A320 before coming to the Board, and when I read that the accident captain, the trainee captain, left seat captain, had just come off of the A320, I wondered about this. As we know, the Airbus has the non-moving throttles, and I'll have to admit, the first couple of times you're flying the Airbus, it's very uncomfortable thinking, oh, my gosh, I can't really push the power up, it will come up. And then over time, you develop confidence and you monitor your engine instruments pretty darn carefully to make sure they're doing what you want them to.

What I'm wondering and, first, Dr. Abbott, does your data show anything where you may have had -- and we know that the trainee captain in the accident said that he expected the autothrust to work. He said he thought the autothrust would still work unless he manually disconnected it. He believed that the autothrottle would come out of idle to prevent it from going below minimum speed. That was the theory, at least, as he understood it. That's from his interview summaries.

So do you have any data to show that maybe coming off of an airplane where the autothrust is always engaged and you don't have to mess with it, any data to show that that could lead to airspeed complacency or overreliance on the autothrottles or anything like that? It was supposed to be a short question. My apologies. It turned into a long one, but hopefully a short answer.

DR. ABBOTT: We don't have data specifically on that circumstance. We did have data that showed in some cases overreliance on the automated systems.

MEMBER SUMWALT: Overreliance on --

DR. ABBOTT: Overreliance on the automated systems, and sometimes that was based on not a full understanding of the automated system behavior.

MEMBER SUMWALT: Thank you.

Dr. Sarter.

DR. SARTER: No, if you ask me for data, I don't think I have that. I would like to point out though that you could actually add one more step to what you just described which makes things difficult, and that is, imagine, for example, you have somebody who is first officer on an A320, then moves maybe up to first officer through various steps to 777 or some other airplane that has backdriven throttles, and now move further up the chain to captain and start on a DC-9. I think there is an additional problem step there because you have somebody moved back to an airplane that is much less automated to begin with.

I think also that in a way, on both airplanes, whether or not the throttles move, you could say the autothrust function is there and the pilot could start overrelying on it.

But another issue could be, we talked earlier again about expectation driven monitoring. So if I'm used to dealing with a throttle or a thrust lever that's in a detent position and never moves, and now I switch, do I even still expect that movement? So I think it is fantastic to have that movement and help me out, but does the pilot actually have the expectation of it anymore if he has flown or she has flown an airplane for, say, 2 years where the thrust lever never moved?

So it's one thing again is what we provide and it's another thing what the pilot does with that based on his or her expectations.

MEMBER SUMWALT: Thank you very much.

CHAIRMAN HERSMAN: Member Rosekind.

MEMBER ROSEKIND: Quick question, and either Dr. Abbott or Dr. Sarter. I'm curious, we're talking human performance and automated systems. So how extensive is the literature on other human factors like distraction, fatigue, time pressure, workload? When we start adding those things into this system, is there big scientific literature on that or what, those other things that could affect it?

DR. SARTER: There is a sizeable literature I think on all of the topics you mentioned: distractions, interruption management, task management, all of that. It is not necessarily literature that reports on research that was conducted in the context of aviation automation. To me, that is not a big issue as long as we understand to what extent it generalizes or doesn't.

So in those areas, there's a lot of literature, yes, but we need to carefully figure out to what extent we can use it in this context, I think.

MEMBER ROSEKIND: Great. Thank you.

CHAIRMAN HERSMAN: Do the parties have any follow-up questions? Asiana.

CAPT. KIM: No.

CHAIRMAN HERSMAN: Okay. APU.

CAPT. MIN: No more questions.

CHAIRMAN HERSMAN: Air Cruisers?

MR. O'DONNELL: No questions.

CHAIRMAN HERSMAN: Boeing.

MS. BERNSON: No questions for Boeing.

MR. O'DONNELL: San Francisco.

MR. McCOY: No other questions, thank you.

CHAIRMAN HERSMAN: Thank you. FAA.

MR. DRAKE: No further questions.

CHAIRMAN HERSMAN: Okay. Mr. LeBaron, back to you.

MR. LeBARON: Capt. Cox, we have time for one question from you.

CAPT. COX: Yes. I'd like to direct this to Dr. Abbott or Dr. Sarter really. We have two controls on an airplane that are fundamental in every airplane, the control yoke and the throttle or thrust levers. Those are fundamental.

So it's one thing to overlook the position of a FMA or a presentation on a display or a button or a switch. It's another thing entirely to overlook a primary flight control. Can you think of in your studies any examples of accidents, incidents or other events that you studied where the pilot simply overlooked completely for a period of time a primary flight control like a throttle?

DR. SARTER: So the short answer is no, I cannot give you a particular study on that. I do want to mention one thing that has been studied but not specifically to flight controls, and that is the issue of the ineffectiveness of cuing by absence. I think that's an important issue to think about in this context here as well, which is -- let's have two hypothetical cases.

Let's have a pilot who expects that the throttle will not move but the throttle moves. That is very likely to capture their attention. However, if the situation is the other way around and it's the absence of the movement that they should detect, that is usually something that is much less effective.

So I think it's a general problem that has been studied in other contexts, but not to my knowledge specifically to the flight controls.

CAPT. COX: I have one more for Capt. McKenney, if I could. Maybe I'm going to trump you here. Have you flown the A320?

CAPT. McKENNEY: Just in the simulator.

CAPT. COX: Let me ask you personally your experience.

What's the difference in the tactile feedback in an A320 versus 777? And you can be general or specific and talk about not only the feel of it, but also the trim feel.

CAPT. McKENNEY: Are you talking between the stick and the yoke or what do you mean by the tactile feedback?

CAPT. COX: The controls you actually move to cause the airplane to change position.

CAPT. McKENNEY: Yeah, in the Airbus, I've flown a couple of them in the simulators, but they all flew pretty much the same. There's not a lot of tactile feedback, and I've flown a stick in the Air Force. So more or less it was just you set your pitch and the aircraft trim to that, where in the 777, the 747, 67s, whatever, is that you do have the tactile feedback when you are moving it. It shows you that it's a heavy aircraft or not, if that's what you're getting at.

CAPT. COX: Okay. Thank you.

CAPT. McKENNEY: And to the previous question, I just wanted to add something, if I could, was -- I forgot what it was that you asked me, but the -- I'm trying to think what the question was that you asked before because, I apologize, but --

CAPT. COX: Well, examples of prior accidents where somebody just seemed to tune out one of the primary flight controls.

CAPT. McKENNEY: Oh, okay, yes, yes. Something I think is important to point out is, as pilots, we have clean wings out there. We're developing very good airplanes. We're developing these approaches to get us in at the minimum fuel. And right now with the coming in high and fast on approaches, the throttles are always, almost always at idle until the last minute. And it's one of my concerns that I'd like to bring out because we have to look at what the unintended consequences of that are.

So if I hit a certain altitude, whether it's final approach, fixed or whatever, but if the approach is designed for me to be at idle all the way to the final approach fix, and I rely on that automation and nothing happens for the last 15 minutes, and then it's supposed to come up -- that's if nothing happens, but it's just an interesting thing that we've noticed in our report, in our data that we saw, is that there's a lot of that going on. So when we say, well, the throttles aren't spooled up, in the old days, they were always spooled up, but now they're always in idle because I'm high and fast and I'm coming in and just saving at the last minute on most of my approaches around the country.

And the other thing I'd like to say, too, if I could, that I think is important is, Madam Chairman, you hit it right on the head the way you explained it, the telephone call. That's exactly what out study found, the same thing. And to answer your question real quickly on that is, we need to make the pilots proactive instead of reactive.

And I think it goes to Mark Rosekind also, sir, is that we get a lot of our training in fixed based simulators where we watch things happen. We watch the automated systems do it. We push the buttons, watch it happen, watch it happen, and over time, the pilots are watching it happen, and we're not being proactive anymore. That's why I'm saying we need to have a flight path management policy that makes up proactive, that we're using system, so we have to turn our training around so we're not teaching people to be reactive. We want to be teaching them to be proactive.

And in the stalls and upset recovery that we've been working on the last 3 years, we're dealing with prevention which also will help us here. So I think that's another area that we need to look at, is how do we prevent unstabilized approaches? So again, if we go back to 10,000 feet, 5,000 feet, we make the pilot proactive, that they're actually looking for all those threats and errors that they can accumulate, so they never get to the point -- which is the way we did the training in the past, we actually expected them to get to the stall, to the unstabilized approach before they recovered. And in the work that we did on those studies, is if we don't ever get there, then we don't have to worry about it. We still need to know how to recover from it, but if we can prevent it in the first place, and start that missed approach at 1,000 feet, 2,000 feet, whatever it is and say, you know what? This approach is over because we already know it's going downhill fast.

And that's where I think as an industry we can help do a little bit, to answer your question. Thank you.

MR. LeBARON: Thank you, Capt. McKenney.

We're going to shift gears a little bit after dinner. So I'd like to go through the IOUs up to this point.

So just to reiterate again, we covered this one once, but Mr. Myers from Boeing, the formal process, the level of warnings, that was going to be Exhibit 2X.

The second item is Mr. Kwang-hee Lee, the Korean Office of Civil Aviation, and that is the most current Korean Flight Safety Regulations in English, and that will be Exhibit 2Y, as in Yankee.

Number three, Capt. Byeong-geoun Yoo from Asiana Airlines, confirm whether or not the training slide with the highlighted area was pre- or post-impact, and you can do that by just providing an e-mail to me.

Then fourth, Mr. Myers, data to support the statement that Boeing assumes pilots are good at monitoring. That will be Exhibit 2Z, as in zulu.

And all of those are due by January 18, 2014, and that's all I have.

CHAIRMAN HERSMAN: Great. Thank you, Mr. LeBaron. And thank you all. I think, Dr. Sarter, you gave me a new term that I'm going to enjoy using a lot, disturbance management, and so I thank all of you all for your willingness work with us in our disturbance management of our process yesterday, and we will be back for a late night tonight.

We're going to have a quick dinner. We will be back from dinner to start our Panels 4 and 5 at 5:15. We're adjourned until 5:15.

(Whereupon, at 4:28 p.m., a dinner break was taken.)

E V E N I N G S E S S I O N

(5:25 p.m.)

CHAIRMAN HERSMAN: Welcome back. We now will proceed with our last panels of the day. Again, because of our cancellation due to the weather yesterday, we are completing the hearing in one day. And that has meant that we are combining the appearance of Panels 4 and 5. They're still focused on their discrete subject matter, but they will all appear before us today in this evening's session. I'll turn it over to Mr. LeBaron.

MR. LeBARON: Thank you, Chairman Hersman.

So the combined Witness Panel 4 and 5 is composed of the following individuals, from my left, and nearest the Board of Inquiry: on the first row we have Mr. Mike O'Donnell from the Federal Aviation Administration; Assistant Deputy Chief Dale Carnes from San Francisco Fire Department; Jason Shively from Oshkosh Corporation; Mr. Marc Tonnacliff from the Federal Aviation Administration; and Chief David Whitaker (Retired) from Aircraft Rescue & Fire Fighting Working Group.

On the second row starting on the back left is Mr. Richard DeWeese from the Federal Aviation Administration; Mr. Jeff Gardlin from the Federal Aviation Administration; Mr. John O'Donnell from Air Cruisers; and Mr. Bruce Wallace from the Boeing Company.

The NTSB technical panel is composed of, starting on my right, Mr. Bill English; Mr. Jeong-kwen Park; and co-leads, Mr. Pete Wentz and Ms. Emily Gibson, and Mr. John DeLisi.

I now ask that the witnesses please stand to be sworn. If you'd raise your right hand please?

(Witnesses sworn.)

MR. LeBARON: Chairman Hersman, these witnesses have been pre-qualified, and their respective experience and qualifications appear in the docket as exhibits in Group 1.

As discussed during the pre-hearing conference, during this round of questions by party representatives, Mr. Rob Hentges will act as the party spokesman for Air Cruisers.

I now turn the questioning over to Mr. Peter Wentz.

MR. WENTZ: Thank you, Mr. LeBaron.

Mr. Huray, if you could please bring up Exhibit 6V, Mr. Carnes's presentation?

And when we get that up, Chief Carnes, if you'd like to start with your presentation at this time?

CHIEF CARNES: Yes, sir. Thank you.

Good evening. Again, I'm Assistant Deputy Chief Dale Carnes of the San Francisco Fire Department, and I'm in charge of the Airport Rescue Division at the San Francisco International Airport. This evening I've prepared a brief overview of the ARFF and emergency response to the Asiana 214 crash.

The initial impact for Asiana 214 occurred at 1127 hours. Approximately 12 seconds later the FAA tower dispatched an Alert 3 in progress to all three fire stations. At 1131, 2 minutes after being dispatched, and 3 minutes after the initial impact, the first ARFF unit, Rescue 88, arrived on scene, followed 37 seconds later by Rescue 9.

Upon seeing that the initial passenger egress pass on the left side of the aircraft were not threatened, both units immediately attacked the fire in engine number 2, which was resting against the right side of the aircraft. By 1133, a little less than 6 minutes post-impact, all seven airport firefighting companies and two paramedic units were on scene. The paramedics were beginning to collect casualties and initiate triage. Approximately 1 minute later, the first of 56 ground ambulances arrived on scene.

At 1138 ARFF personnel entered the aircraft for interior search and rescue. By 1146 all trapped passengers and those who had remained behind to assist had been removed from the aircraft. And by 1218, approximately 19 minutes after the impact, all fire in the fuselage had been extinguished with the support of companies from San Francisco and mutual aid from San Mateo County.

At 1301 the last patient from the airfield was transported by ambulance. All ambulatory passengers had been relocated to the terminals and a significant number of those passengers later self-reported injuries and underwent secondary triage. By 1758 the last of those passengers were transported from the terminals to area hospitals. All told, 56 ground ambulances, 2 medical helicopters, and 2 buses transported 179 patients to 12 area hospitals.

There are many areas of this incident that we consider to be successes. Among them are: the arrival of ARFF units within 3 minutes of the initial impact and without prior alert notification; the extinguishment of the fire in engine number 2, which was wedged against the right side of the aircraft, in 90 to 120 seconds; the rescue of all trapped passengers from -- extrication of all the trapped passengers from the aircraft within 19 minutes of initial impact and prior to the arrival of mutual aid resources; and the extinguishment of all fire within 47 minutes of the initial impact. And this includes a large interior fuselage fire that initiated and rapidly spread within an area that could not be effectively reached by interior hose line.

In spite of our successes, we feel that there are many lessons be learned here. And just some of the areas that we have focused on for improvement are: incident management of large scale ARFF incidents; managing a large survivor population in the midst of an ongoing firefighting and rescue operation; locating and collecting non-ambulatory injured over a large accident scene; compatibility among radio systems of responding agencies; fighting interior fuselage fires where the effectiveness of interior hose streams is severely limited; and the effective use of a high reach extendable turret, or HRET, and piercing nozzle.

To that end we have pursued the following post-accident initiatives. To enhance our training program all personnel have received an additional 40 hours of ARFF training provided by personnel from the Dallas/Fort Worth Fire Training Research Center. Advanced ARFF training for all officers will begin in 2014, and we have adopted the DFW HRET training curriculum. Also in 2014, we'll be bringing in the blue card incident management training system to train all officers. And we are currently implementing the EMT-3 triage system to enhance our mass casualty incident management capabilities, and to ensure that our system of dealing with MCIs is seamless with the other agencies in San Mateo County.

Also in the area of EMS we are upgrading our EMS supervisor's position to 24/7 status, which will further enhance our incident management capabilities in the medical branch. We have budgeted for a dedicated mass casualty vehicle to be housed in one of our fire stations. We have improved radio interoperability between ARFF and mutual aid resources. We are developing strategies to lessen the potential for firefighting vehicles impacting accident victims. We are adopting the Passport Accountability System for tracking all fire and EMS personnel on scene, and we're actively developing policy and procedural guidance in both the administrative and operational levels.

And lastly, we have increased both our communication with and our involvement in the mutual aid community to include multiple debrief sessions with surrounding agencies.

Again, sir, these are just some of the initiatives we put into place or currently working on. And this does conclude my presentation.

MR. WENTZ: Thank you, Chief Carnes.

We're going to start in with some things. And Mr. O'Donnell and Mr. Tonnacliff, some of the FAA questions that I'm asking you, if it's not your general area and it may be Mr. O'Donnell's just feel freely between you to say, you know, you'd rather take the question.

But what I'd like to start off with is, you know, talking about the San Francisco Airport. And I know that, you know, as ARFF standpoint says there's different indexes. Could you talk about what type of an index the airport is and, you know, what qualifies it to be that index?

MR. TONNACLIFF: Thank you. The 139.315 describes in it that the length of the air carrier aircraft and the average daily departures determines what the index is. San Francisco is an Index E airport, which is the largest, serving aircraft over 200 feet in length.

MR. WENTZ: What about certification, FAA certification? What type of rules or policies do you have to have in place for an airport of that size?

MR. M. O'DONNELL: Good evening.

Certification really is a -- it's based on Part 139. It's a regulation which covers commercial service airports. There's 540 of them in the United States. And really, it's based around the self-inspection program that we hold the airports to. It's a higher level of safety than you would find at a general aviation airport. Aircraft Rescue and Fire Fighting is just one piece of it. It could be snow removal. It could be vehicle operations, marking, lighting, signage; all the things that occur on the taxiways and the runways are basically governed under Part 139.

So it's an overarching regulation, but at the core of it is a self-inspection program where the airport daily inspects its own airport movement areas and notes discrepancies. The ARFF training is also a big piece of that and there are requirements under the regulation for ARFF training, vehicles and equipment, and the index as well.

MR. WENTZ: Okay. Thank you.

Chief Carnes, I'm going to ask you, on the day of the accident, what was your staffing levels that day for personnel and for equipment?

CHIEF CARNES: At the airport we have three fire stations spread strategically throughout the airport. We maintain seven firefighting units, including four ARFF vehicles. Each one of our -- three of our four ARFF units are staffed with two firefighters. Our fourth ARFF unit is staffed with two firefighters and one lieutenant. We have a similar staffing on our other company, so we generally have a daily staffing of approximately 23 firefighters or ARFF personnel and one shift commander, which is a captain.

MR. WENTZ: In your presentation you spoke about mutual aid. So after the incident happened, then you called the -- you said mutual aid came to support you. How does that system work?

CHIEF CARNES: Well, we operate under the California Master Mutual Aid program, and we work within Region 2. The state is divided into six regions. We function in Region 2 and regularly work with the other -- with our allied agencies, both providing and receiving mutual aid.

In this case, in the event of an actual Alert 3, we automatically request mutual aid from San Mateo County and additional companies to respond from the city. We use a system that's referred to as a box system. The box is nothing more than a predetermined or predesignated response package, and, in which case, we get several companies from both the city and from San Mateo County and both with their own independent command element coming with them.

MR. WENTZ: Chief Whitaker, I have a question for you about once, you know, an incident like this happens and, as Chief Carnes said, the Alert 3 went out, they start heading to the scene. How does the fire department set up on an accident scene?

CHIEF WHITAKER: Thank you, Mr. Wentz. And per your instructions, I'll try to remain generic and not specifically speak to this accident.

Most airport fire departments have developed standard operating procedures and guidelines, and one of those is the SERP pattern, or the Standard Emergency Response Pattern, which is based on a clock system. And it's important to predetermine where many of those incident command positions will be for future oncoming companies, mutual aid companies, and others from outside the airport environment that certainly aren't familiar with some of our setups.

Those SERP patterns are typically based on wind and terrain. Also time of day, weather, and other factors like that play a role. So once the firefighters have trained on a SERP type pattern, and whether it's a clock system or based primarily on wind, they know predetermined locations as to how to set up on the aircraft, whether it's on fire, whether it's a passenger or cargo type of aircraft, whether passengers are self-evacuating, whether they can see smoke, and many other factors the incident commander has to make and decide in those first 3 or 4 minutes.

And positioning of that equipment in those early stages of this incident is critical. Because if you allow many companies to box up into those areas, then sometimes you're not able to maneuver them or reposition them as the -- if the incident escalates.

MR. WENTZ: Okay. Thank you.

Mr. Tonnacliff, when it gets back to, you know, talking about an airport of this size, what type of training is required from the ARFF or the fire department?

MR. TONNACLIFF: The 139.319 provides what I like to call the dirty dozen. It's 11 subject areas, and then you also need to have an annual recurrent fire training in a pit. To go along with this, the FAA also has an advisory circular, which we expand upon the different areas of the 11 subjects of required training.

MR. WENTZ: Is there any difference in, say, initial training to a recurrent training for a firefighter?

MR. TONNACLIFF: The initial training, as long as they get the -- your dirty dozen subjects and the recurrent training is the same. There is what Chief Carnes -- or excuse me -- what the Chief talked about earlier, in a 40-hour class, that gets the individual a lot of training up front initially.

MR. WENTZ: And who does the -- or checks the oversight from the FAA's point of view if this training has been met?

MR. TONNACLIFF: We have airport certification safety inspectors that go around to the airports annually and inspect the training records at the airports of the ARFF personnel.

MR. WENTZ: Okay. Thank you.

Chief Carnes, of all the training that goes on in San Francisco, how are your training requirements implemented for your firefighters?

CHIEF CARNES: We actually have a multi-layered training program. We meet the requirements -- our training delivery comes in the form of daily company drills, weekly what we call captain's drills, monthly redcap drills, which are multi-company and basically involve the entire shift that we have three times a month, as well as ongoing specialized training and our annual live burn training.

MR. WENTZ: In like, say, just a few seconds could you tell us what a redcap drill entails?

CHIEF CARNES: Well, the redcap drill, again, we use it to capture several layers of training. We use it to do our time trials to make sure we're meeting our response times. We also practice runway crossings under Alert 3 conditions. Depending on -- they're only scenario based drills, so depending on the scenario and where we're staging the drill, we will also practice positioning of our apparatus, basic incident command, implementation of the HRET, et cetera. We try and wring as much training value out of them as we can.

MR. WENTZ: Okay. I'm going to transition a little bit and move onto fire scene management now and talk about incident command.

Chief Whitaker, can you explain the incident command system and how it operates?

CHIEF WHITAKER: The national standard is the NIMS, National Incident Management System, a course taught initially through the National Fire Academy and Emergency Management Institute, and local state agencies as well. The 100/200 series is the lower level initial learning, and the 300/400 levels are for your higher-level incident managers.

In the fire service we always use an incident management NIMS type system. Even on a daily basis on our small -- if you have two engines and a truck and an ambulance responding to a house fire, then we establish command and go through some of those initial steps. That way the firefighters are used to hearing those commands and understand the different terminology within the NIMS system.

And so, on a larger scale more complex incident, as the NIMS system allows you to expand and put operations and medical and different branches and different divisions in place, the firefighters understand that terminology and they understand the direction and who they report to within this system. And of course as the incident begins to stabilize and you're able to, you know, retract the NIMS positions, it works the same way.

But when you call for command, it doesn't matter whose voice you hear, whether it's the captain or the chief that has taken his place, you call command, you ask for or request the resources that you need, and they're provided to you.

MR. WENTZ: So, Chief Carnes, on the day of the accident who was your initial incident commander?

CHIEF CARNES: Our initial incident commander was the on-duty shift captain for that day.

MR. WENTZ: And so, for each shift you have an on-duty captain that takes that role on?

CHIEF CARNES: Yes, sir.

MR. WENTZ: And as Chief Whitaker was saying, it sounds like with, as it escalates and gets larger, your incident command can get larger as well?

CHIEF CARNES: Yes, sir. Generally the way we work is that our on-duty shift captain is the initial incident commander, meaning that once he gets on scene he establishes command, establishes his command post, declares his strategy, creates an initial incident action plan, initial assignments, and orders additional resources as needed. Obviously, in the event of an actual Alert 3, then that's done automatically and we get a considerable amount of resources coming in.

As Chief Whitaker alluded, you know, the system is designed to expand based on the size and complexity of the incident. And an Alert 3 that involves firefighting, rescue, and a mass casualty incident is a significant and complex event. Because of that we've already pre-packaged into our response, our box or response package from the city, not only the number of engines and truck companies and ambulances, but also a sizeable command presence in not only battalion chiefs but also more senior assistant chiefs that respond and then assume command upon their arrival, take over the strategic command role, and then place the on-duty shift captain in a more operational or tactical level command concentrating on the ARFF operation.

MR. WENTZ: So on this day, then, you had somebody else take over control of the incident command?

CHIEF CARNES: Yes, sir. The assistant chief who was in charge of Division 3, which is the south end of the city, that day.

MR. WENTZ: Okay. And so, what -- could you kind of talk us through what a handoff would be, then, when that chief got on scene?

CHIEF CARNES: Upon arrival the chief would report to the already established command post and he would get a structured report from the initial incident commander that would include the incident conditions, the status of all their resources they have on scene, and any resources that have been ordered or requested, the initial incident action plan, the primary tactical objectives that have been established and/or met, and any concerns that the initial incident commander might have.

MR. WENTZ: So I guess that's the normal practice every day that you see no matter what type of a fire it is. It doesn't have to be an aircraft fire?

CHIEF CARNES: Not only is it normal, it's routine for us. Our department runs a little over 10,000 calls a month with a large number of those being working fires, including what we call greater alarm or multi-alarm fires in a very complex urban environment. So what that means is our chief officers are very experienced and very capable incident commanders, so that's -- that process, not only is it spelled out very clearly and very structured in our command post operations manual, but it's something that -- it's a procedure we practice on a routine weekly basis.

MR. WENTZ: Okay.

Chief Whitaker, I'd like to talk a little bit about on scene safety. These ARFF rigs are very large rigs. There's a number of them around the scene at the time. What do you do to practice safety with other firefighters, the police, the airport safety officers, passengers, and crew that around the aircraft, in maneuvering these aircraft -- or the ARFF rigs, excuse me?

CHIEF WHITAKER: Well, through our initial and recurrent training of operating these vehicles we try to maintain monthly mini drills with the different agencies on the airport, including operations and police, medical, fire. Different airports are certainly set up different ways. We were a municipal department that serviced the airport, but I know in many other airports, whether they're Port Authority or they rely on outlying companies, they do it different ways.

But we would train primarily without the luxury of having hundreds of people on the scene. We would call it functional drills or mini drills. And so, we would set these trucks up and set up different positions, whether it be cones or other type of equipment, have the drivers maneuver these vehicles, raise the high reach extendable turrets, raise the booms, spray water, try to put them through different situations that may --

that they may encounter with different types and sizes of aircraft.

MR. WENTZ: When you talk about this operator of this rig, I know that in some of the interviews that we had there was a rider along with them and some they don't. How much more does that place on the operator without a rider in the rig with him?

CHIEF WHITAKER: You know, we were fortunate that we rode three to a rig. I know many places ride two. But when you're a single operator of these type of rigs, you know, 35, 40 feet long, limited visibility in some cases, especially behind you, or trying to monitor a camera at the same time you're operating one or possibly two joysticks, operating the bumper turret as well as a high reach extendable turret, and if you -- if the officer or the second person off that vehicle is committed to pulling hand lines or doing search and rescue, and that operator is by himself attempting to operate those radios, not just to his fire department but to the FAA tower or operations, it's quite difficult and quite complex for one person to assume all these roles and tasks. So it's -- for that driver/operator to monitor his extinguishing agents, to maneuver the vehicle, to -- again, a multitude of things that he has to do alone in that cab once that second person leaves the cab is quite difficult.

MR. WENTZ: Mr. Tonnacliff, what kind of guidance does the FAA provide the fire departments about moving ARFF rigs?

MR. TONNACLIFF: The FAA has Advisory Circular

150/5210-23, which deals with aircraft rescue firefighting vehicles, primarily the high reach. And within there we have -- in the appendix there's actually something that is like a test that they can to through. As an example, we provide an example for driver skill ability, and we do recommend that they have a backup man. We also have a couple ARFF training DVDs that we provide to the certificated airports.

MR. WENTZ: Thank you.

Chief Carnes, in your opening presentation you spoke about the challenges with communication. Could you talk a little in depth about that?

CHIEF CARNES: Well, prior to July 6th, the City and County of San Francisco had invested a lot of effort and money to enhance and improve the radio communication systems for the fire department -- $7 million alone I believe was what we spent at the airport -- with the goal of having interoperability between the different elements within the city and county, meaning that units at the airport would be able to talk to units from the city and also ideally mutual aid resources from San Mateo County.

That development process was still underway when the Asiana 214 accident occurred. And because of some recent rebanding of radios that was part of that process, we weren't ultimately able to have those elements communicate on the same radio frequency. Most large-scale fire incidents that I've been on, communications is generally one of the challenges we face.

Because of that we're used to dealing with it. It was something that we were able to overcome rather quickly, one, by falling back on what additional frequencies we had available to us, as well as face-to-face communications when necessary.

And also, because of prior established relationships between our chief officers and the chief officers from the mutual aid agencies that came into the airport, you know, the ability to have those relationships already in place and set up a unified command really allowed us to overcome that challenge without any negative impact to the incident.

MR. WENTZ: So you kind of made changes on the fly that day to make it work for you. Have you made changes to fix the system as a whole?

CHIEF CARNES: We made a series of changes. Primarily, we now have the ability to patch fire department radio frequencies from the City of San Francisco and from mutual aid resources in San Mateo County directly onto the radio frequencies at the airport. So we now truly have interoperability where we can all communicate on the same frequency. And our goal that we plan to reach in 2014 is to be able to do the same with San Mateo County EMS.

MR. WENTZ: Okay. I'm going to transition now to talk about tactics and the piercing nozzle.

Mr. Shively has been sitting there waiting for a question, I'm sure, so, Mr. Huray if you could bring up Exhibit Q, Photograph 1?

And Mr. Shively, if you could briefly describe the high reach turret and the piercing nozzle?

MR. SHIVELY: Yes, sir. The high reach turret is a device that's mounted on the vehicle to deliver an agent to the fire scene itself. I may use the term "Snozzle" throughout my presentation here. That's the brand name of the high reach turret from Oshkosh Corporation. So if I confuse HRET and Snozzle together you know what I'm talking about.

The HRET itself is mounted to the top of the vehicle. In the photo up there it is the white boom. There's two sections to the boom. There's a lower boom and an upper portion. At the base of the boom on the vehicle there is a pivot mechanism that allows the vehicle to -- or allows the Snozzle to be moved left and right. At the tip of the upper boom is what we call the head. That is where the primary water/foam nozzle is located. Inside that upper boom is also an inner boom that is extendable forward to exchange the reach of the nozzle itself away from the vehicle.

Also on the end of the head there's the ability to have the airport specify different options. We can put lights at the end of the head, color cameras, infrared cameras. We also have the ability to discharge auxiliary agents, whether it's dry chemical or a clean agent. And then also there's a piercing tip that can be specified by the airport that's shown in the red tube on the photo up above. Could we move to Photo 5, please?

MR. WENTZ: Mr. Huray could you find -- it may take him a second to find it, but go ahead, and while he does that -- so why was the piercing tip developed?

MR. SHIVELY: Well, to kind of continue on my previous comment, the boom itself allows the operator to put that water nozzle away from the vehicle into a better position, depending on conditions, than a standard mounted roof turret. So the boom is actually able to raise up, so if there's a high-mounted engine -- that's not the one I was looking for. I was looking for one that had a boom raised.

MR. WENTZ: That's true. I believe it's the one with the -- the last one in there with the two --

MR. SHIVELY: It might be number 6?

MR. WENTZ: And how long has -- is this your --

MR. SHIVELY: Yep, that's the one. So this photo here shows the boom raised up in the horizontal position up above, and it also shows the piercing tip deployed. This photo does show -- we offer two different lengths: a 50-foot and a 65-foot variant that could be chosen by the airport for their particular needs.

MR. WENTZ: And who operates this?

MR. SHIVELY: The controls for this are located in the cab. In the Striker vehicle the operator sits in the center of the cab. On the right-hand side is what we call the officer's seat. In between those two is where we have the controls for both the roof turret, the high reach turret, or the bumper turret, depending on what's specified with the vehicle. So at any point in time the operator can move to his right to operate it, or if there is a person in the captain's chair or officer's chair, he can move to his left to operate it.

MR. WENTZ: Okay. When you deliver a vehicle like this what type of training comes with it?

MR. SHIVELY: From a basic standpoint -- and I can talk in specifics to the SFO delivery, which is very common to our typical deliveries. Typically there's a 2-week class that is involved. The truck is delivered to the airport. We dispatch an Oshkosh representative to the airport. The first week of training is basic training on the vehicle itself and its operation, and the second week is centered around the Snozzle.

So the two vehicles that were delivered to SFO that had Snozzles received 2 weeks of training. There was a third unit that was delivered in 2010 that just had a roof turret; that vehicle received 1 week of training.

MR. WENTZ: Okay. And, Chief Carnes, how were the penetrating nozzles used in the Asiana accident?

CHIEF CARNES: The penetrating nozzles or the HRET as a whole? We used the HRET both as an elevated master stream, similar to what you saw in that one picture, after the fire had breached through the top of the fuselage, and we also used the piercing nozzle component. We pierced the aircraft three times.

MR. WENTZ: And who decides to do this?

CHIEF CARNES: Well, we had the option of a couple people -- a couple different people making that decision. Obviously, our lieutenants, our company officers, are responsible for task level supervision; however, our driver operators are also fully trained and capable of making that decision in the absence of direct supervision.

MR. WENTZ: Mr. O'Donnell or Mr. Tonnacliff, what type of FAA guidance is there when it comes to a piercing nozzle?

MR. TONNACLIFF: Again, as I stated previously, the FAA has published Advisory Circular 150/5210-23. Within that we provide guidance on use of the high reach extendable turret. We don't directly tell them when to pierce, but we do provide information about piercing. There are two different types of penetrating nozzles that are currently on the market, and Oshkosh provides one of them, and they operate in different manners. But we do provide guidance on how to pierce, but we don't provide any guidance really on when to pierce.

MR. WENTZ: And for Chief Carnes, in some of the interviews we saw some hesitancy to when to pierce the aircraft. There were talks of people still inside the aircraft. Could you talk through that for me?

CHIEF CARNES: Well, I don't think so much it was hesitancy. Our personnel are trained from the beginning of their career to never conduct exterior fire attacks simultaneously with an interior fire attack. In this case, through the early part of the incident we had both trapped passengers and personnel inside the aircraft extricating those trapped passengers. So, again, I wouldn't characterize it as hesitancy. I would say that it was a decision, a tactical decision made based upon their training and their experience, and good risk management to wait till those personnel had been extricated -- they had extricated the passengers from the aircraft and the personnel had evacuated the aircraft to go ahead and start piercing and employ an exterior attack.

MR. WENTZ: Okay. Mr. Shively, in one of our Exhibits, L, it's the video from the tower that day. And it showed the ARFF vehicle backing up and the piercing nozzle is hanging from it, so it seemed that that nozzle had broke. Can you explain to us why that happened?

MR. SHIVELY: Sure. The piercing nozzle in just its name is developed to pierce the fuselage much like you would take a pencil and insert it into a soda can.

CHAIRMAN HERSMAN: Mr. Shively, could you speak more directly into the microphone, particularly for our interpreters?

MR. SHIVELY: Okay. Thank you.

CHAIRMAN HERSMAN: Thank you.

MR. SHIVELY: So, with the piercing nozzle, it's designed as a tube with a sharp point on it that's allowed to pierce the side of the fuselage and dispense the agent on the interior of the aircraft. With that being said, there is no cutting mechanism to it, so if there is any relative motion between the piercing tip and the fuselage, that would put a force into the boom itself. To protect the integrity of the boom and the head, we allow that piercing tip to sheer.

In the video that was from the scene from C225, the rig R10, I believe, was the one that pierced it, then it broke as it was being extricated. That vehicle was allowed to go back, refill with water, return to the scene, and they continued to use the vehicle with the high-volume nozzle to fight the fire after the fact.

MR. WENTZ: So the tip is actually designed at some point to break, and that would be a normal function, if it got put into a position where it was going to snap anyway or --

MR. SHIVELY: Correct. There's always a risk of when the piercing nozzle has pierced the ability for that to become lodged or stuck. So we allow that to sheer itself if there is a side force put on that nozzle that we don't expect. That serves -- or protects the integrity of the boom and the rest of the piece of equipment so it can continue in further use.

MR. WENTZ: Okay. Great.

We're going to transition now to the rescue portion of this. And Chief, if you could -- Chief Carnes, excuse me, if you could talk to us about the rescue portion that went on that day?

CHIEF CARNES: Well, we -- again, we had at least four trapped passengers in the aircraft, and we also had a number of passengers and non-fire airport personnel that were inside the aircraft trying to assist. And so, immediately upon -- as I explained in my presentation, the first-in units, you know, they addressed the first priority of ensuring that the egress pass of the passengers was safe and protected. And then once that was complete, the passenger evacuation, they then went to their next priority, which is -- life safety is always our highest priority, and that involved a rescue in this situation.

Because of the fact that we did have fire that was extending into the fuselage, we also took hose lines into the interior of the aircraft to support those rescue efforts and protect our personnel.

MR. WENTZ: So, in total, how many personnel did you have inside the aircraft that day?

CHIEF CARNES: Not all at the same time because the incident went -- the rescue effort went on for several minutes, but we had a total of 9 of our 22 personnel that were inside the aircraft at any one time during the rescue.

MR. WENTZ: Either Mr. O'Donnell or Mr. Tonnacliff, if you could quickly -- I know that from the American Airlines 1420 accident there was a recommendation of zero to 165 on the numbers of ARFF rescue personnel available. Could you talk a little bit about that?

MR. M. O'DONNELL: Yeah, I'll talk about that. So under Part 139 we don't get into the details of numbers of firefighters that have to be on a department to respond. We do talk about sufficient and qualified firefighters that are able to operate the vehicles, that are able to meet the response times, that are able to dispense the minimum amount of agent per the regulation.

This topic has come up many times before and we've looked it through the Airport Cooperative Research Program in at least two separate studies to define what -- if there are any appropriate levels of staffing that could or should be mandated for airports. And the studies were conclusive that the costs to implement something like the proposals we've had over the past 5 years of having requirements for firefighters, or requirements for certain specific types or numbers of vehicles, far exceeded the benefit versus the cost.

So any rule making that we would have to initiate to change this regulation would be based on whether it's a cost benefit or not. The two studies proved that it was indeed much more expensive and not cost beneficial to go into requirements of some of the recommendations that have been out in the past with the numbers of firefighters that have been proposed in previous FAA bills, so we have kept the regulation where it's at.

The regulation is pretty clear that sufficient and qualified people to do those things that I just mentioned are tested annually with the certification inspection that occurs at the airport.

MR. WENTZ: Okay. We're going to move on to triage.

Mr. Tonnacliff, if you could talk about mass casualty and what airports do from the FAA's side for triage?

MR. TONNACLIFF: The FAA requires the airports to hold a triennial drill. Every 36 consecutive calendar months they must hold a mass casualty drill in which they test and implement their full system at the airport with some type of drill. Mass casualty is one of the drills that they hold. We like to see it with an aircraft.

MR. WENTZ: Okay. Chief Carnes, do you know when the last drill was conducted in San Francisco?

CHIEF CARNES: For at least the last decade the San Francisco International Airport has chose to conduct our large scale mass casualty drills on an annual basis instead of a triennial basis. The one exception -- or two exceptions actually -- one would be this year because we had the actual Alert 3 incident, and in 2012 we actually switched up the scenario on our mass casualty drills so that it was a off-airport scenario that the aircraft had went long and actually landed on the outskirts of the City of San Bruno.

But, in general, again, we do that annually, every year, and have for at least a decade. And it involves all the mutual aid agencies in San Mateo County, as well as the units from the City of San Francisco that were involved in the Asiana 214 crash.

MR. WENTZ: Mr. LeBaron, I think I'm down to the minute here. I've got one last question, if I could?

Could you describe how the triage went that day of the accident and kind of take us through, you know, from the rescue on to the triage, how it went through on that day?

CHIEF CARNES: Well, the objective of triage -- the short answer is to do the most good for the most people. It basically requires that our first arriving paramedics organize the casualties into color-coded groups that are based on their level of acuity. It involves a very rapid, approximately 1-minute, assessment assessing their respirations, their perfusion, and their mental status. And based on the findings of the assessment, again, they're categorized into one of four categories that, again, are color-coded.

Red would be immediate or those that are most critical and whose survival depends on surgical intervention in a rapid fashion. Yellow would be delayed. Those are seriously injured, but not as critical as the immediate category. Green would be walking wounded or minor injured, and then black would be those that are dead and/or expected.

MR. WENTZ: Okay. Thank you. I've used all my time up and I'm --

CHAIRMAN HERSMAN: Mr. Wentz, if you have questions that are along these lines that you need to finish up, please go ahead and do that.

MR. WENTZ: Well, okay. Thank you.

Chief Whitaker, what type of, I guess the guidance that is out there for the ARFF community with respect to triage?

CHIEF WHITAKER: Yeah, and Chief Carnes is describing the START system, Simple Triage and Rapid Transport, that has become the industry standard. And he mentioned the red, yellow, green, and black either tags or ribbons that are used, depending on the complexity of the -- or depending on the type of severity of the injuries.

But the START system is very simple. You don't have to be a paramedic or an EMT because it is so simple, and it's based on a quick evaluation even -- he described you spending 30 seconds to 1 minute. One responder even spending 30 seconds could only do in a 10-minute period, you know, 20 victims. But the dead and dying -- you know, the red, green, and black, again, based on respirations, perfusion, and mental status -- but those that are deceased or obviously in a dying state are left in that position. And that's a hard call for a first responder.

Normally as firefighters we arrive on the scene and there's 8 or 10 responders for one patient and we're able to work those full arrest and those seriously injured trauma full arrest type patients. But in a mass casualty the roles are reversed. You may only have a dozen responders for 100 patients. And so, you have to do the most good for the most number of people. And that's a difficult decision for those first responders to have -- to leave someone, or if you don't get to them in time, the yellow become red and the green become yellow, and their condition worsens.

MR. WENTZ: Okay. Thank you.

Chairman Hersman, thank you for the time for that. And I'll turn it over to Ms. Gibson.

MS. GIBSON: Good evening. We're going to transition now to airplane cabin crashworthiness and occupant protection.

Mr. Huray, if you could please pull up Exhibit 6-AB?

Mr. Gardlin, I understand you do have a presentation? Please proceed.

MR. GARDLIN: Yes, what I would like to do is very briefly just cover some of the occupant protection --

CHAIRMAN HERSMAN: Is your mic on? And if it is on and it's not working, would one of you all at the front table switch seats with him if the mic isn't operating?

MR. GARDLIN: It says "on."

CHAIRMAN HERSMAN: Okay. Why don't you switch seats with someone in the front row?

Thank you very much, Mr. O'Donnell.

MR. GARDLIN: Okay. Is that -- yeah, that's working.

Okay. So what I would like to do is just give a very brief overview of the regulatory requirements associated with occupant protection.

Briefly, what we're talking about here is mitigating the effects of an accident. Obviously, accident prevention, accident avoidance is the primary safety objective. We don't want to have accidents. But in the event that there are accidents then we have to take very seriously the need to try and make them as survivable as they possibly can.

The accident rate is very low, but we are having an increase in traffic growth. And so, given that, it means that even at an extremely low rate we probably will have accidents. I have a couple of graphs to illustrate that, and I won't really spend much time on these. But the FAA has published a couple of reports on trends in accident survivability. I've cited them here.

And what they basically show is that the accident rate and the fatality rate in accidents are both dropping and that the percentage of accidents that are survivable is increasing. But in this case, if we superimpose that at a little bit of a more magnified level with the amount of air traffic, it's pretty clear that there is an increase in traffic and it's likely that we will see accidents, even at a very, very low rate.

So, from an occupant protection standpoint we basically try to do three things. First off, direct protection of the occupant through survivability, protection against injuries, impact survivability. We attempt to make the ability to get out of the airplane as fast as possible. And thirdly, we try to extend the time available for egress as long as possible.

So what I've cited here are sections from Title 14 of the Code of Federal Regulations, all of which are in Part 25, applicable to transport category airplanes. I won't attempt to go over each of those regulations, but in terms of what we've done, this is sort of the same thing, but with the element identified with the associated regulatory changes that we've made.

So we've done a number of things in each of the areas. This goes back to approximately the mid 1980s is when a lot of these improvements started. Some of the early changes were made in fire safety and then occupant injury protection, and then to speed egress from the airplane in the event there is an accident.

This is a more literal summary of those. We've done things for flammability. The large interior surfaces now have to meet a very stringent heat release requirement. Seat cushions have also been addressed, a very stringent requirement. We've more recently imposed a requirement for the ability of the airplane to resist penetration of an external fire using insulation that has highly fire resistant properties. Escape slides themselves are now or have been made heat resistant from the effects of a post-crash fire. We've implemented changes to markings to access to exits, and to the capability of escape slides to make it faster to evacuate.

In terms of occupant protection, one of the big changes was imposing requirements for dynamic testing of seats and including quantitative occupant injury protection criteria. And in addition, we increased some of the static load factors on other items in the airplane as well.

We've also done a lot of things to address in-flight fire safety, but that tends to fall more into the realm of accident prevention or accident avoidance, so I don't intend to really spend any time on that. Just some examples over the last years of airplane accidents where we've had a whole loss, but there was in fact 100 percent survivability in the accident.

And then actually I'm running a little bit ahead, but to summarize, I guess, accidents they are very rare, but for at least the foreseeable future we will probably continue to have them; however, they are more survivable than ever. And recent experience, by virtue of something like that, suggests that a lot of the changes that we've made over the last several years are actually having a positive effect and that we're seeing much improved survivability in accidents that might not have been had they occurred earlier.

MS. GIBSON: Thank you.

I think because you all have presentations and then we're going to go into a line of questioning, we're going to have you guys move to -- from the back row to the front row.

And Mr. Huray, if you could please bring up Exhibit 8-AC?

Mr. DeWeese, I understand that you have a presentation? Please proceed.

MR. DeWEESE: Yes, I do. Thank you. I've prepared a presentation summarizing the crash safety requirements for transport aircraft seats.

The FAA has established safety requirements for aircraft seats that are intended to reduce the risk of injury and death in a severe but survivable crash. The requirements consist of static load factors applicable to most interior components, and dynamic tests to verify both seat strength and the occupant impact protection. Design requirements are also levied for specific seat configurations.

Static requirements have been in place for many years and are intended to protect the occupants in a minor crash landing, usually expressed in terms of multiples of an item's weight, commonly referred to as g's. The magnitude of the load direction has been increased over the years as aircraft technology has changed.

I've got a table here summarizing the load factors in the various directions for transport aircraft. They're applied in all directions and with the highest level being the 9 g forward direction.

Now, the strength of seats and restraints are verified statically by applying loads slowly. Basically, a body block is strapped into the seat using the restraint system, and then the loads are applied to the body block, as you can see here.

Now, accident studies were conducted to look at the accidents that were occurring, and it indicated that survivable crashes can exceed the severity level corresponding to the required static load factors. The predominant force vectors in these cases studied were forward and then a combined vertical and forward direction. Dynamic tests confirmed that seats to meet only the static load factors didn't provide a high level of safety when they were subjected to a severe but survivable impact level.

Could you advance to the next slide please? My clicker isn't working.

Basically, laboratory tests revealed that many seats that were designed to meet the static load factors did not perform well when dynamically tested. There's a video that's supposed to play here. Here we go.

This is a seat that had passed the static tests, and you can see here multiple failures occurred. The seat tore loose from its mounting point to the floor, and the seatbelt for the occupant in the rear row failed.

To provide protection in these severe but survivable crashes, requirements were implemented to evaluate occupant protection in the two most likely impact scenarios. I have the horizontal direction at a 10-degree yaw, at 16-g peak acceleration, and then the combined vertical/horizontal, essentially a 30-degree pitch condition, at a 14-g peak acceleration. Could I have the next slide please?

Here we have an example of a horizontal test. It has a 10-degree yaw. The floor for the front seat is deformed, as sometimes occurs in an airplane crash. This evaluates the seat strength and its flexibility along with chest, head, and leg injury protection that's being evaluated by the test dummy in the second row. Next slide, please.

This is an example of the combined horizontal/vertical orientation test, essentially 30 degrees from vertical. It evaluates the seat strength, particularly the seat pan and the supporting structure under the occupant, and directly assesses the spine injury protection by instruments inside the test dummy. Can I have the next slide, please?

In both these tests, test dummies are used as occupants. This gives us a realistic loading for the seat and the restraint systems, and the instruments inside provide a quantitative assessment of injury severity. The risk of injury from an out of position belt is also evaluated during dynamic testing, as is the shoulder belt tension that has to be limited to specific levels.

The criteria that are used to evaluate these injuries permit evaluation of the head, chest, spine, and legs. And these all come from readings inside the test dummy that we're able to interpret using these injury criteria.

Now, new types of seats and restraint systems that weren't specifically addressed by the original requirements, they have to also provide the equivalent level of safety when compared to the other standard seats and restraint systems. And this is done by conducting research to derive the appropriate requirements, and then the FAA issues special conditions to implement these new requirements. The next slide, please.

Inflatable restraints, in this case belt-mounted airbags, are an example of a new technology that was addressed by the issuance of these special conditions. You can see here the bag deploys from the belt and gets between the occupant and the seat in front, lowering the head injury potential.

And all these requirements that I've been discussing stem from the regulations I've cited here. Thank you.

MS. GIBSON: Mr. Huray, could you please pull up Exhibit 6-W?

Mr. Wallace, I understand you have a presentation? Please proceed.

MR. WALLACE: I'd like to start off by thanking the Board for allowing me the opportunity to participate in this panel. My name is Bruce Wallace. I am an Associate Technical Fellow for the Evacuation Systems Engineering at the Boeing Company. I am a member of the NTSB Survival Factors Team for this accident and participated in the on-site investigation after the crash.

I want to take a moment and express Boeing's condolences to the families who lost loved ones in this accident. Our thoughts are also with those injured, and we wish them a speedy recovery. For Boeing, safety is our top priority and we strive every day to make flying as safe as possible.

In this presentation I'll briefly describe key events in the impact sequence, and then I'll give an overview of the 777 design features that contributed to the occupant protection during the crash and how they performed in this accident.

This graphic shows the position of the airplane during the initial impact when the main landing gear and aft fuselage hit the seawall at over 100 knots. The severe impact loads caused the main landing gear to separate from the wings. The impact also resulted in extensive damage to the aft fuselage structure and separation of the tail. The aft galley, one large cargo container, and a great deal of baggage were released onto the runway. The airplane continued to travel down the runway resting on the nose gear and the engines.

As the airplane continued down the runway, the left engine separated and the airplane became partially airborne. With the nose gear in contact with the ground, the airplane rotated counterclockwise approximately 330 degrees and impacted the ground in a downward and sideways direction. As the airplane slid to a stop, the lower fuselage was peeled open toward the right side of the airplane. The right engine separated and came to rest next to the fuselage.

A fire ignited in the right engine oil tank outside the fuselage. From video review of the accident, black smoke can first be seen coming out of door 1-left, approximately 15 minutes after the airplane came to a stop. Two escape slides inflated inside the cabin, but all passengers and crew were evacuated from the airplane using alternate exits. This does not diminish the fact that there were fatalities and injuries.

Now, I'm going to turn to an overview of how Boeing designed the 777 for occupant safety in an accident and how this airplane performed during the accident.

The industry's work on airplane safety and survivability of airplane interiors emphasizes three areas: surviving an impact, surviving a fire, and airplane evacuation. Keeping the severity of the multiple impacts in this accident in mind, the airplane performed extremely well with respect to each of these goals during this accident.

As I mentioned, the first safety design goal is to allow the occupants to survive an impact. The FAA has established certification requirements for emergency landing forces as well as dynamic flight and ground loads that airplanes must be able to withstand. The 777 fuselage and interior structure are designed to meet or exceed those certification requirements. Airplane seats and restraints are subject to those same requirements, plus additional static and dynamic load certification requirements, including a 16 forward dynamic load and a 14-g downward dynamic load, as Rick had pointed out.

The airplane performed extremely well during the impact sequence despite being subject to several severe impacts that likely exceeded the design goals. The passenger seating area remained intact and the overhead stow bins did not fall on passengers or block their evacuation.

The next safety design goal is to allow the occupants to survive a post-crash fire should one occur. The 777 fire protection features included engines and main landing gear that are designed to separate under high-impact loads to prevent fuel tank rupture. If a fire occurs, insulation blankets and cabin materials are designed and resist the spread of fire.

In this accident the main landing gear and the engines separated, as designed, and the fuel tanks did not rupture. Although a fire did occur in the right engine oil tank, its propagation was slowed significantly to allow for evacuation of all passengers and crew.

The third safety goal is to allow occupants to evacuate the airplane. The 777-200 is designed and tested to allow up to 440 occupants to evacuate within 90 seconds. This 90-second evacuation standard is required by FAA regulations, and the testing is done with half the exits blocked and under nighttime emergency lighting conditions. Some of the features that expedite evacuation are: simple operation doors, seats and other interior components designed to stay secure and not block the aisles, and automatic self-inflating escape slides.

Despite the extensive structural damage to the airplane in this accident, the doors opened, the seats and interior components stayed clear of the aisles, and the occupants were evacuated from the airplane.

It is difficult to foresee and design to all possible events that may occur during an airplane accident. This accident included multiple extremely severe impacts that exceeded the design and certification requirements. Despite this, the 777 occupant safety features performed extremely well and contributed to the high survival rate.

This performance of the 777 airplane highlights the benefits of the work that the regulators, operators, and suppliers have done, along with Boeing, to increase airplane safety and accident survivability. Thank you.

MS. GIBSON: Thank you.

Mr. Huray, could you please pull up Exhibit 6-AA?

And Mr. O'Donnell, I understand you have a presentation?

MR. J. O'DONNELL: Yes, we do. Thank you, Ms. Gibson. I'd also like to take the opportunity to thank the Board for Air Cruisers to participate in this process.

So, I'm going to provide a presentation: the background of our company, and also evacuation systems and what it takes to certify them.

So, Air Cruisers started in 1929 as a maker of aviation safety equipment. Back in World War II we made the Mae West life preservers and barrage balloons. We actually invented the inflatable evacuation system in the 1950s. We were purchased by Zodiac in 1987 and became Zodiac Aerospace in 2007.

So what is an evacuation slide? It's a safety device that rapidly inflates for emergency evacuation from an aircraft. It's required on commercial aircraft when the sill height exceeds 6 feet from the ground. It's normally installed beside the cabin on the door or housed in an external fuselage compartment. Many slides also double as slide rafts in water landings, as you can see on the bottom from the Hudson incident.

There are several primary major components on slides. You have the packboard and lacing cover that contains the slide assembly and provides the mounting hardware to attach to the aircraft door. Then we have the inflatable tube structure, and then the inflation system, which is comprised of the compressed gas reservoir, a valve regulator, hoses and aspirators. And also for slide rafts we have a survival kit, which also includes a raft canopy, as you can see at the bottom.

Some of the typical slide particulars include -- there's a view there at the left of the back of the packboard. You can see at the lower edge the attachment fittings. At the top there's a top latch. So there's three points in the 777 that attach the packboard to the aircraft. At the bottom you see a girt, which actually attaches the inflatable to the girt bar, and the girt bar then attaches to the aircraft floor fitting.

So how does an evacuation slide work? Well, the pack slide system is installed on the aircraft door. The girt bar is attached to the aircraft floor fittings, as you can see in the middle picture. When the aircraft door is armed and opened, a cable is tensioned that releases the slide pack from its packboard. The pack then begins to drop downward and the inflation cable is pulled, opening the valve to initiate inflation.

Once inflation starts, gas rushes to the aspirators opening the flappers, which then entrain ambient air. We actually entrain about two-thirds of the air into an inflatable from the ambient conditions. The unfolding of the slide occurs in stages controlled by frangible links, as you can see in the pictures on the right. The aspirator flappers close when the pressure builds to about 2 psi. The slide is rapidly inflated and immediately ready for use once fully extended.

So, what are the requirements? Well, the primary governing document is the FAA TSO-C69c. To develop and qualify and certify slide systems typically takes 3 to 4 years. Some of the requirements of the TSO include: inflation time -- the slide has to inflate within a maximum of 6 seconds; evacuation rate -- it has to be able to handle at least 70 people per minute per lane. So for a 777 with two lanes that means 140 people per minute minimum. It has to be able to deploy in 25 knot winds from any direction, also resist the environment, which we, you know, look at sand, dust, salt spray, fluids, et cetera.

Like we said earlier, we have to have to radiant heat reflective fabric. That started in 1983. We have to meet all the flame resistance and smoke and toxicity requirements for the FARS, and we have to be able to deploy the unit after it's soaked overnight at -40 degrees, and also when it's soaked overnight at +160 degrees. And the slides also have to function at adverse attitudes. That's any combination of the landing gears out. And for potential water ditching, we have to be able to prove that the slides do work in that condition as well, and even if it's deflated, as a shoot.

In addition to the TSO requirements, we have FAR requirements and we have OEM requirements, including vibration, shock, on-aircraft repeatability, full-scale evacuation demonstration, and also acceleration loads. You'll see at the bottom right there's a CAD depiction of the centrifuge testing that our systems go through. And our systems go through that testing to prove that they can meet the anticipated crash loads, but then afterwards we also have to test the systems to make sure they can deploy after the crash loads have occurred. Thank you.

MS. GIBSON: Thank you. I'd like to talk more about the occupant protection concept that Mr. Gardlin showed in his presentation, Exhibit 6-AB, slide number 6, and how FAA regulations and guidance keep passengers safe on aircraft.

Mr. Gardlin.

CHAIRMAN HERSMAN: Ms. Gibson, you know what? If you don't mind, while they're getting that ready, let's just take a 5-minute stretch break. I know everyone's struggling a little bit right now, and so we're going to just take a really quick 5-minute stretch break. We want everyone to be able to pay attention to Panels 4 and 5.

We're adjourned for 5 minutes.

(Whereupon, at 6:34 p.m., a brief recess was taken.)

CHAIRMAN HERSMAN: Welcome back.

Ms. Gibson, thank you. And we look forward to hearing your questions for the panel.

MS. GIBSON: Mr. Gardlin, Amendment 25-6497 addresses static load testing. What is the static load testing for most interior components? What does that mean?

MR. GARDLIN: Well, as Mr. DeWeese discussed, there are both static and dynamic test requirements -- or dynamic and static load requirements. Virtually everything that's in the -- any significant item of mass inside the fuselage is required to be restrained to a given set of static load conditions. And we saw that chart there on what all of those are.

CHAIRMAN HERSMAN: Mr. Gardlin, can you pull the mic a little closer?

MR. GARDLIN: So the static load cases basically apply to everything inside the fuselage, including things like overhead bins, closets, galleys, the inserts that go into galleys, and the seats as well. So it's a means of assuring that they have adequate strength.

MS. GIBSON: What are the interior component design requirements?

MR. GARDLIN: Well, in addition to things like static load factors and restraint, there are flammability requirements for, again, virtually everything that's in the fuselage. There may be requirements associated with egress depending upon where something is located. If it's located in an egress path, there may be certain considerations that apply to make sure that we have adequate access to exits and so on. So, those would be, I guess, the three main things that would apply to those items.

MS. GIBSON: Okay. Thank you.

Are interior components subjected to dynamic load testing?

MR. GARDLIN: In general they're not. There is some exception. If an item is associated with a seat and forms an element of the seat's ability to perform its function, then it could be subject to dynamic testing. But in general, they are not.

MS. GIBSON: Why not? What are the drawbacks from doing those tests?

MR. GARDLIN: I don't know if it's drawbacks. I mean, obviously a dynamic test is a more complex test, and depending upon what you're trying to test there might be logistical issues with doing it. But I think the main reason is that most things can be substantiated adequately through a showing of strength through a static load, and the issues that would be addressed in a dynamic test really don't come into play.

MS. GIBSON: Mr. DeWeese, what are the performance requirements for aircraft seats?

MR. DeWEESE: Well, as I showed in the presentation earlier, the aircraft seats have to meet both the static test requirements outlined in 25.561 and in the dynamic testing requirements called out in 25.562.

MS. GIBSON: Okay. How do you verify seat strength and occupant impact protection?

MR. DeWEESE: Well, again, the seat strength is through the static test, and then the dynamic test supplies more load in a rapidly applied fashion because of the dynamic nature of that test. So that verifies the strength of the seat actually two ways. Now, occupant protection is only evaluated during the dynamic test, and that's evaluated using the readings from the test dummy and observation of how the belts restrain the occupant.

MS. GIBSON: Okay. Mr. Wallace, how does Boeing meet the certification requirements for aircraft seats?

MR. WALLACE: So, survivability is greatly influenced from seat design. The 777 seats themselves are designed, manufactured, and tested by our seat suppliers. Boeing works -- we work directly with them to ensure that they meet the criteria that has been spoken over here, the safety standards as spoken by the FAA here, as it's installed in the airplane. So we take our seat systems and do test them in these load tests to demonstrate that we can meet those g forces.

MS. GIBSON: Mr. DeWeese, there's many new novel seats in aircrafts today: the pod seats, the lay-flat seats, et cetera. How are those certified?

MR. DeWEESE: Well, those seats to the greatest extent possible have to meet the same standards as any other seat. But when a seat has a novel feature that the regulations don't directly address, then we usually conduct research to determine what the requirements should be to make sure that that seat performs to the same -- rises to the same level of safety as the regular seats do. Once those requirements are determined, then the FAA publishes those in special conditions that outline what additional items need to be done to show the level of safety is met.

MS. GIBSON: What is a special condition?

MR. DeWEESE: Well, it's basically a type of regulation that outlines -- sometimes it's additional items to be done, additional tests, additional evaluations. Sometimes it actually replaces some parts of the regulation, say, doing a test in a different way than it would be done for a normal seat, to account for those novel features.

MS. GIBSON: Some of the seats in the Asiana accident airplane had shoulder harnesses. Why do some seats require shoulder harnesses?

MR. DeWEESE: Well, the dynamic testing regulations require that head impact protection be provided for the occupants.

Now, it doesn't specify exactly how to do that. It just provides an objective measure looking at the head accelerations from the test dummy. Depending on the seat design, particularly how far apart the passenger rows are, this can be done in different ways. If they're close enough together, then the seatback can be used as an effective energy absorber if the person flails over onto the seatback and it absorbs that head impact injury reducing the risk of injury. If the rows are far enough apart, then the person flailing forward with just a lap belt restraining them would miss the seat in front entirely, again protecting the head from impact.

It's those seats that fall in between there where the seatback is too far away to really be much of an energy absorber, but it's close enough to present an injury risk. That's where something like a shoulder belt or an inflatable restraint system can be used to provide head impact protection.

MS. GIBSON: So why don't all seats have shoulder harnesses?

MR. DeWEESE: Well, basically because it's not necessary in most cases to provide the head impact protection. It could be more efficiently provided using the energy absorbing seatback if the seats are close enough together.

MS. GIBSON: Is it more safe or less safe?

MR. DeWEESE: Well, there's no doubt that a shoulder restraint or an airbag that would preclude contact with the seat in front, that would provide a higher level of safety than contacting the seat in front for sure. But all of them meet the minimum standards in the regulations.

MS. GIBSON: What methods or considerations exist for certifying aft-facing seats?

MR. DeWEESE: Well, aft-facing seats have to meet the same standards as the forward-facing seats in virtually the same test conditions and everything else.

MS. GIBSON: Would it be better to have aft-facing seats on airplanes?

MR. DeWEESE: Well, they certainly have the advantage of spreading the load out on your body more evenly and supporting the body well. But there are some practical considerations that is one reason you really haven't seen them popular on large aircraft. One of the reasons is, is that the -- since the body would be applying forces much higher on the seat than a lap belt does, now you've got more force going into the seat -- from the seat going into the floor. So the only -- to keep the floor loads to levels that it can withstand, generally you have to build energy absorption into the seatback. This means that the seatback would need to flex forward some to absorb energy to manage those loads going into the floor.

You can imagine that if you have several rows of these seats and they all deflected backwards, you could definitely impede the ability to egress the aircraft. So you would end up probably having to move the seats farther apart, reducing the number of rows you could have in the aircraft. Like I said, there's some practical considerations as to why they haven't become popular for passenger seats.

MS. GIBSON: What about side-facing seats?

MR. DeWEESE: Well, side-facing seats is another example of our -- where we did research to look at the proper requirements. They were considered a novel installation, and so a whole series of research tests and programs were conducted to determine what the proper requirements should be for side-facing seats. And those culminated in special conditions that were issued just early this year that provide special tests and evaluations so that the side-facing seats provide just the same level of safety as our forward-facing seats.

MS. GIBSON: Mr. Wallace, in your presentation you specifically had mentioned passenger seats are designed to exceed to static and dynamic load certification requirements. Can you explain how you exceed those requirements?

MR. WALLACE: So, clarification on that is that we do design -- as Jeff was pointing out here, we do design our airplane components and all the items of mass in there to a 9-g static load and 6-g. This is a sustained load condition that we design to, and we design to meet or exceed those conditions. So, as far as the seats are concerned, in the statement that I started off with, is there's these additional requirements from the FAA. One is on the static load all components in the airplane are at 3-g side load. The seats themselves go up to a 4-g side load.

In addition to that, we do do this dynamic testing of the 16 g and 14 g to demonstrate that we can protect the occupant. And those kind of dynamic loads, those are an impulse load, immediate load, a little bit different than the static load, which is a sustained load.

MS. GIBSON: Mr. Wallace, were the flight attendant jump seats on the Asiana airplane 9 g or 16 g?

MR. WALLACE: They were 16 g.

MS. GIBSON: How did they perform in this accident?

MR. WALLACE: There was 13 jump seats on this airplane. They were located throughout the airplane at the four exit pairs, or the eight exits. We inspected all of the jump seats on scene and the jump seats at Doors 1 through 3 were all intact. The Door 1-right had a twisted seat pan, and the Door 3-left had some deformity on that seat pan as well, but they were all intact.

At Door 4, where we lost the aft end of the airplane and a significant amount of floor structure underneath it, two of the jump seats did end up out on the runway with the initial damage to the tail end of the airplane. And then there was a third jump seat that ended up right aft of the airplane on the final impact, in the final resting zone. So those ones were all in the area of the airplane that was -- that exceeded the normal 9-g forces that we design our component to.

MS. GIBSON: Mr. DeWeese, are flight attendant jump seats subject to the same dynamic testing as passenger seats?

MR. DeWEESE: Yes. They, in fact, meet the exact same requirements as the passenger seats with the forward test and the vertical test.

MS. GIBSON: So, if a 16-g jump seat is attached to a 9-g wall or partition, does it do any good?

MR. DeWEESE: Well, you know, it's interesting. There's a common misconception -- and it's understandable if you just look at the magnitudes of those two colloquialisms, and just to explain them. The seats that only meet static tests are commonly referred to as 9-g, referring to that forward pull on the seat, and, of course, 16-g seats are the dynamic seats.

But in reality, the mismatch isn't there. The 9-g test actually ends up being a 12-g test because the 9 g's is multiplied by a 1-3-3 fitting factor to account for fitting wear that could occur over the life of the seat. And so, it's really a 12-g static being compared to a 16-g dynamic.

But it turns out, when the 16 g rule was being developed there was a lot of seat -- tests of prototype seats were done. And essentially what was determined was that the loads imparted into the floor during a 16-g forward test did not exceed the floor strength that was required by the 9-g static requirement. So there actually is a good match between the loads generated by a seat tested at 16 g's and the available structural strength provided by an item that's certified to the 9-g requirements.

MS. GIBSON: So when they're tested, they're tested as a component, as a unit: the jump seat to the wall or the jump seat to the partition?

MR. DeWEESE: Well, what's actually done is -- as Mr. Gardlin referred to earlier, if a jump seat is, say, attached to a partition, then that's really considered part of the seat at that point, and the whole thing is tested together dynamically. But if it's attached to something like a galley, a very large item, then essentially what's tested is the attachment points to that item. In other words, a section of the wall of the galley where the jump seat bolts on, that's emulated in the fixturing on the sled when it's tested to make sure that the attachment's good, but the entire galley is not dynamically tested. It's statically qualified once again.

MS. GIBSON: Okay. Mr. Gardlin, what are the requirements for seat configuration on an airplane?

MR. GARDLIN: Well, there's a number of requirements that apply. Most of them -- once the seats themselves have been shown to meet the appropriate structural and injury criteria, then the bulk of the rest of the requirements are to ensure that the seats are positioned in a way that allows for egress. There are also requirements, for example, that the seats and the oxygen mask drops line up appropriately.

But there's a number of requirements to ensure that there are adequate paths for evacuation leading from each seat row to a passage way to an exit, or in the case of a twin aisle airplane, to cross aisles and lead between aisles and then lead to exits. So it defines, I guess, the entire arrangement.

MS. GIBSON: So what is the FAA's role in implementation when an air carrier chooses to reduce spacing and put on more seats?

MR. GARDLIN: Well, the FAA basically is responsible for approving that sort of design change, and it's considered a change to the type design of the airplane. Specifically which part of the FAA that may oversee it I think depends in some degree on how extensive the modification is. And so, it may be that the FAA Flight Standard Service looks at that and it may be that the Aircraft Certification Service looks at that. But it is considered a change and it requires a full FAA approval.

MS. GIBSON: Thank you. I'm going to switch to evacuation systems now, but for Mr. Gardlin, what guidance exists for evacuation certification design?

MR. GARDLIN: Well, we have advisory circulars. We have advisory circulars on how to conduct the full-scale evacuation demonstration that was alluded to, or in some cases, depending upon the extensiveness of a change, that could be potentially done analytically. We have advisory material that covers the configuration requirements for an airplane, so where seats can be positioned relative to aisles and things like that, how closet doors have to be restrained, for example, so they wouldn't open into an evacuation path. So there's a number of advisory circulars that cover those areas.

MS. GIBSON: Mr. Wallace, Mr. O'Donnell mentioned in his presentation a full-scale test. Can you explain what that is?

MR. WALLACE: Yes, so a full-scale test is -- as I mentioned in my presentation, we do demonstrate for the 777 that we can load the airplane up with a full configuration, high-density seat configuration. And the full-scale test is a benchmark test that we run for certification to demonstrate the capability of the airplane for egress with that maximum passenger. It's conducted with half of the exits inoperative, and it is a time event. We do emphasize that there's a sense of urgency to get out. And so, the full-scale is taking the whole entire airplane and filling it with people and doing a test.

MS. GIBSON: Mr. Gardlin, why is the requirement for half of the exits?

MR. GARDLIN: Well, as mentioned, it is a benchmark type test. It's a means of comparison against a common standard so that we have an idea of how efficiently an airplane can be evacuated. The historical precedent for half of the exit dates back 40, maybe 50 years. And I think it's recognition that in an actual evacuation you may not have all exits available. So as a way of standardizing it, it has been to use one half of the number of exits. And that is done by using one exit from each pair of exits.

MS. GIBSON: Mr. O'Donnell, what kinds of tests are slide rafts subjected to before they are certified?

MR. J. O'DONNELL: Like I said in my presentation, you have the TSO requirements, which are very diligent, and I went over those in detail. You also have the dynamic tests, the centrifuge tests. Like I said before, the slide actually has to be put through the 9-g and the forward and 3-g inboard loading on the centrifuge. And then afterwards you have to prove that we can deploy that off the door to make sure it still works.

MS. GIBSON: So the dynamic testing you're referring to, that's the spin test?

MR. J. O'DONNELL: That's the centrifuge test, yeah. Some may consider it static, but if you've ever seen it, I wouldn't call it static.

MS. GIBSON: Two slide rafts inflated inside the cabin. How frequently do you get reports of slide rafts inflating inside cabins?

MR. J. O'DONNELL: I have been at Air Cruisers for 26 years and have never had a report of our product deploying inside an aircraft.

MS. GIBSON: Can you describe the teardown testing that was accomplished in July?

MR. J. O'DONNELL: Yes. There were several packboards and slide rafts returned to Air Cruisers from San Francisco. I think of note what was found was that on Door 1-right and Door

2-right that inflated inside the aircraft, the packboards were still on the doors. When we looked at those, or when my team looked at those packboards in New Jersey, we found out that the release mechanism had actually suffered catastrophic failure. So it was overwhelmed by the forces that were seen during the accident, which then forced the slide to release inboard and then inflate.

MS. GIBSON: Have you ever seen damage like that before in an in-service aircraft or in an aircraft that had been involved in an accident?

MR. J. O'DONNELL: We have never seen anything like that after certification tests, and even after the Heathrow test -- or crash rather of the 777 several years ago that Bruce was at. The release mechanisms did not suffer that sort of failure.

MS. GIBSON: Mr. Wallace, then has Boeing ever seen a 777 accident where there was damage similar to what we saw?

MR. WALLACE: No, I haven't seen that occurrence in any of our in-service reported cases or with -- like he had mentioned here, in any accident that we've seen, we haven't seen that kind of damage.

MS. GIBSON: The damage that you saw here with Asiana, how does that compare to the Heathrow accident?

MR. WALLACE: Damage to the slide or the airplane?

MS. GIBSON: The airplane.

MR. WALLACE: The airplane? That airplane was totally intact. The difference between these two is that that airplane -- if anybody's familiar with it, at Heathrow, it lost power coming up to the landing, so it did crash in short of the runway. The fuselage and all the interiors were all intact, seats were intact, and it was in pretty decent shape. All the slides did deploy.

The difference here is that we did have an impact that was more of a vertical impact versus the horizontal when we hit the seawall. So it did hit the tail end in a vertical type impact rather than in a horizontal. In addition to that, once it did go through its rotation, its final impact was still going down the runway and there was -- in looking at the video, there was a significant down and side load to the airplane that's not typical what we've seen with accidents.

MS. GIBSON: Mr. O'Donnell, what did you find in the tensile test?

MR. J. O'DONNELL: When we took brand new packboards and subjected them to the tensile testing to try to recreate the failure that we saw in the release mechanism, we saw loads that were orders of magnitude higher than what we would have expected based on our centrifuge testing.

MS. GIBSON: So how does that compare to the certification loads that you test to?

MR. J. O'DONNELL: I don't want to draw conclusions. They were orders of magnitude higher, so I would say at least three to four times higher.

MS. GIBSON: Mr. Wallace, was this type of impact sequence something Boeing envisioned during certification testing?

MR. WALLACE: No. As I mentioned, we do follow the safety standards that have been developed by the industry and that the FAA imposes on us. And judging by the accident -- it's hard to say. We are still under investigation. We do have a few -- another planned test for our slides so that we can hopefully determine what the final failure mode was for that. So, further investigation, we'll see if there's something that we learn from this accident that we might be able to use towards our safety improvement.

MS. GIBSON: Mr. O'Donnell, what sort of challenge would you have to meet a higher threshold if you were to increaser the g-loads that you test to?

MR. J. O'DONNELL: It basically would involve the release mechanism and the release shaft material. So we've already done some brainstorming with our engineers in that regard, but it's premature to really look at anything until we finish up the testing that will be occurring in January.

MS. GIBSON: Based on the ongoing testing, has Air Cruisers made any changes to the pack design or testing?

MR. J. O'DONNELL: No we haven't because it's premature based on the -- when the investigation is still ongoing.

MS. GIBSON: Mr. Wallace, despite multiple severe impact loads, we did not see the overhead bins fall on passengers in the

Asiana accident. Had Boeing done something different with their design?

MR. WALLACE: So, as mentioned, over time as we evaluate airplane accidents, we do discover areas of improvements, and stow bins are one of those. The stow bins themselves are also designed to the 9-g forward, 6-g down, 3-g side, 3-g up, and 1½-g aft. In addition to that, we do have some flight and ground loads that increase the up and down loads, so we design our stow bins to meet that. In addition, the stow bins are tested to demonstrate that they can withstand that.

MS. GIBSON: I'd like to go back to Mr. DeWeese. You had mentioned inflatable restraints. Will all aircraft be equipped with this new technology?

MR. DeWEESE: Well, at this point the inflatable restraints are being used for those seat positions where a conventional means of providing head protection, i.e., the motion of the seatback where the occupant pushes it over, isn't available, say, a front row or seats with a long pitch. So there's no actual requirement envisioned to require airbags for all aircraft. That being said, they certainly do provide a higher level of safety and if operators wish to incorporate them, they could certainly have a great impact on survivability.

MS. GIBSON: Mr. Gardlin, so where are we going from here? Are we stagnant? Are we evolving? What are the challenges that you see?

MR. GARDLIN: Well, actually since you mention that, we had probably almost 600 people discussing that very issue last week at a large R&D conference on occupant survivability.

Well, as you can probably imagine, you know, in the course of trying to make improvements, we've prioritized those activities and tried to do the things that would make the most improvement first, and we've been working our way through that.

But no, we're not stagnant. We have initiatives under way to address airframe level crashworthiness. We're looking at means of providing occupant protection or occupant injury criteria that more closely correlate with what we're interested in, which is the ability of someone to evacuate an airplane after an accident. The standard we have now has been to some extent read across from automotive standards, and they're valid standards but they're not specifically geared to the problem that we have.

We're looking at novel ways of giving passengers safety information that they might actually assimilate and use. And we have an extensive R&D prioritization process underway that we are hoping to implement that covers all the areas that I mentioned, the three different regions. So no, it's not stagnant. We have a lot of work ongoing.

MS. GIBSON: Tim.

MR. LeBARON: Mr. Park.

MR. PARK: I'd like to ask question to the San Francisco Fire Department chief, assistant chief.

According to the ARFF regulation, internal regulation, in its manual four emergency vehicles are required to be operated. In this accident how many vehicles were dispatched?

At the San Francisco Airport, according to the internal regulation of the San Francisco International Airport, the manual says that -- the Exhibit O says that it is required to dispatch four emergency vehicles. So in this case of accident, how many vehicles were dispatched?

CHIEF CARNES: For any Alert 3 we dispatch a total of seven firefighting companies, two paramedic units, and one command vehicle. The seven firefighting companies include not only traditional structural engine companies and a truck company, but they also include four ARFF vehicles.

MR. PARK: So, how many emergency vehicles were dispatched then? Not fire trucks. I mean emergency vehicles.

CHIEF CARNES: Are you referring to medical EMS type vehicles, sir?

MR. PARK: Yes, correct.

CHIEF CARNES: We have 2 paramedic units on the airport as part of our response, and then an additional 56 ground ambulances came in as part of the mutual aid response.

MR. LeBARON: That's all the tech panel had.

CHAIRMAN HERSMAN: Thank you, Mr. LeBaron.

We'll now move to the parties. Asiana Airlines.

CAPT KIM: Thank you, Madam Chairman. On behalf of

Asiana Airlines I want to take this opportunity to express our sincere appreciation and gratitude to the first responders and emergency personnel, and to the medical facilities and the medical personnel in the San Francisco area for their efforts and their support in responding to this tragic accident. Thank you.

CHAIRMAN HERSMAN: Thank you very much, Captain Kim.

Asiana Pilots Union.

CAPT MIN: APU has no questions. Thank you, Madam Chairman.

CHAIRMAN HERSMAN: Thank you Captain Min for your participation today.

Air Cruisers.

MR. HENTGES: Yes, I have just one question for John O'Donnell.

CHAIRMAN HERSMAN: And Mr. Hentges, can you just introduce yourself? Because I know folks have been looking to Mr. O'Donnell for the --

MR. HENTGES: Yes, my name is Robert Hentges. I am the Boeing program manager for our Boeing products at Air Cruisers.

CHAIRMAN HERSMAN: And you'll be acting as the party spokesperson since your spokesperson is on the witness stand, right?

MR. HENTGES: Yes, that is correct.

Okay. Mr. O'Donnell, shortly after the Asiana crash some media outlets were bringing up the fact that some 777 escape slide systems were the subject of an airworthiness directive from the FAA. Can you talk about that airworthiness directive and whether it had any bearing on the escape slides on that particular aircraft?

MR. J. O'DONNELL: Yes. That AD was in reference to the release mechanisms on the packboards. It was a service bulletin that we put out and the FAA made it an AD at our recommendation as well because of corrosion. So the AD said to inspect the packboards, if there was corrosion to replace the housing with a new alodine housing. So when we looked at what occurred on the Asiana aircraft, six of the eight had the new blue housings and no corrosion, and the other two were of the original design, but they also have no corrosion. So the corrosion played no role in what occurred.

MR. HENTGES: Thank you. No further questions.

CHAIRMAN HERSMAN: Boeing.

MS. BERNSON: Thank you, Chairman Hersman. Boeing has no questions.

CHAIRMAN HERSMAN: Thank you, Ms. Bernson, for your participation today.

City and County of San Francisco?

MR. McCOY: We have no questions for the panel. Thank you.

CHAIRMAN HERSMAN: Mr. McCoy, you're five for five today. Thank you.

MR. McCOY: Good answers.

CHAIRMAN HERSMAN: Yes. And finally, the FAA.

MR. DRAKE: Madam Chairman, FAA has no questions.

CHAIRMAN HERSMAN: Mr. Drake, thank you for your service as party spokesperson.

We'll now move to the Board Members. Member Sumwalt?

MEMBER SUMWALT: Madam Chairman, you were nice enough to give me extra time on one of the panels, so I've promised that I won't ask questions for this panel, so thank you.

CHAIRMAN HERSMAN: Thank you. I wanted to make sure everyone understood that you weren't going to ask questions to the panel.

MEMBER SUMWALT: I think everybody's glad I'm not going to ask questions. Thank you for your service, Madam Chairman. Thank you.

CHAIRMAN HERSMAN: Thank you.

Member Weener.

MEMBER WEENER: Well, this is an unusual situation.

CHAIRMAN HERSMAN: This is your wake-up autothrottle time, Member Weener.

MEMBER WEENER: Both Mr. Gardlin and Mr. Wallace said there were three things that were important and they were pretty much the same things: occupant protection, exit speed, and time to exit. So in terms of occupant protection, Mr. Wallace, did you see that the 16-g seats performed as expected?

MR. WALLACE: So, as mentioned the 16-g seats are designed to protect the occupants in a survivable crash. The seats that were up in the, what we call Zones A and B -- Zone A is between Door 1 and Door 2, and Zone B is Door 2 to Door 3 -- they were all badly damaged by fire. But they did all -- all the seat legs themselves that we can expect were still mounted to the floor, to the floor tracks.

The Zone C, where we had the significant structural damage, the seats were pretty -- in general, they were leaned back. Some of the legs had come loose or been fractured. There was a lot of legs bent to the left. The overall seats themselves -- since we had lost the lower portion of the fuselage back there, the floor that supports those things was kind of pushed up on one side on the right side. It was very badly damaged.

So, as far as meeting a 16 g, without that structure it's difficult for it to, you know, really consider whether it met -- well, it had demonstrated to meet those criteria. So, as a result of the damage and the fact that they were still able to protect many of the occupants, they performed pretty well considering the damage to the airplane.

MEMBER WEENER: Were the seats in Zone C damaged in the forward direction or was there -- I thought you said there was a backward movement?

MR. WALLACE: Yeah, it's hard to tell what the forces were on the seats. There was -- when we had inspected them, a lot of them had the forward legs had come loose so they were leaning back. With the floor structure as badly damaged as it is, I can't tell if it was because there was some kind of an aft flow to it or how they ended up like that.

MEMBER WEENER: The video that we saw earlier today sort of suggests that at least at the aft end of the airplane there may have been a centrifugal force to the rear.

Were any of the seats -- the bulkhead seats are ones that you are concerned about the head impact criteria; is that correct?

MR. WALLACE: The bulkhead seats?

MEMBER WEENER: Yeah.

MR. WALLACE: The bulkhead seats, I believe, were clear. I'm trying to think of the second -- well, so all of the seats in there are designed and tested to demonstrate that they can meet 16 g. So whether there's a bulkhead there or not, you know, they've been tested in that configuration. And I'm thinking there's enough --

MEMBER WEENER: Were any of those airbag seats seatbelts?

MR. WALLACE: No, they were not.

MEMBER WEENER: They were not. And in terms of exit speed, the 90-second evacuation demonstration was mentioned as a base, basically a benchmark test. As such, is it done with a typical complement of carry-on luggage, or is it just done people only?

MR. WALLACE: So that test is -- there is some criteria in the safety standards that say that we need to put luggage and some obstacles in the aisle-ways. So, yes, it is representative of luggage in the airplane.

MEMBER WEENER: And lastly, in terms of surviving the fire, how did the interior materials perform? This is probably one of the first real opportunities to look at all of those changes that were made back in the mid '80s for flammability.

MR. WALLACE: Correct. As I mentioned, the first signs of dark smoke coming out of Door 1-left was about 15 minutes in. And that would indicate that you've got -- Door 1-left with the attitude of the airplane was the highest point, so the smoke would kind of move that way. But as you've mentioned, in this accident the first was slowed greatly enough that we could get everybody evacuated, including the rescue team able to get some people that could not get out themselves.

MEMBER WEENER: Mr. Gardlin, anything to add?

MR. GARDLIN: Not really. I mean, I think the slow development of the fire does indicate that the materials did what they're supposed to do. And I would agree that the aft end of the airplane probably saw fairly high centrifugal acceleration that resulted in some aft load.

MEMBER WEENER: Thank you.

CHAIRMAN HERSMAN: Thank you.

Member Rosekind.

MEMBER ROSEKIND: Chief Carnes, I know you're back there?

CHIEF CARNES: Yes, sir.

MEMBER ROSEKIND: So, the first question is just, can you give us a sense of how much activity you got going on in the department the year before this accident? I thought I heard you say 10,000 responses a month on fires? Or give us a sense of just how busy you are.

CHIEF CARNES: Well, the San Francisco Fire Department has 44 stations in the City of San Francisco, and then 3 stations at the airport. And collectively, we run approximately 10,000 calls a month, so we're an extremely busy urban fire department. That includes medical aids, fires, technical rescue calls, hazardous materials, airport incidents, and so on.

MEMBER ROSEKIND: And specifically for the airport, what do those numbers look like?

CHIEF CARNES: I don't have that information immediately available, sir. I'm sorry.

MEMBER ROSEKIND: And these are, you know, potentially once in a career kind of activities that happened here. So, just trying to get a sense though of, I mean, your experience in the last year, 5 years even, at the airport, this is a standout activity. I mean, what other kinds of things have you been dealing with? Just one or two examples to get a feel for --

CHIEF CARNES: Well, I've worked at the airport off and on as an officer since 2008. And since that time, I've not only been on the Asiana 214 crash, but also on the San Bruno gas explosion, where we actually provided mutual aid instead of requesting mutual aid. So even though these are what by most terms would be considered career incidents, because of the environment we work in the Bay area, you know, we tend to see pretty complex incidents on a regular basis.

MEMBER ROSEKIND: The other thing I wanted to ask you is, one of us up here, at the Board meeting when this comes to the floor, will certainly ask what changes have happened since the accident. And what's interesting, we're at the hearing now, just a step in between, and you have a couple of slides there that really listed quite a few initiatives that are going on. So it appears you've had quite a bit of support, including budgetary. You had a 40-hour person going to 24/7, a lot of training initiatives.

Can you just tell us a little bit about that? Is it coming from the airport, the city, the county? There's clearly been a lot of push to help you kind of move ahead.

CHIEF CARNES: The short answer would be, yes, it's coming from both the city and the county, the fire department, and my command and administration above me, the airport, and both boards, the airport board and the fire board. The City and County of San Francisco and the citizens of our community take a lot of pride in our fire department. And we feel that we have a -- had a world-class organization before the Asiana 214 incident, and we certainly plan on continuing that afterwards.

Anytime you have an incident of this complexity, regardless of the level of successes that you identify, I think it's just natural to step back and do a comprehensive review of your performance, your capabilities, your training, and look for any opportunity to enhance those things. And that's exactly what we have done and continue to do.

Also in this particular incident we obviously recognized our overall responsibility to the ARFF industry and the nation's, you know, aircraft and airport industry, and because of the low frequencies of these events, that we have to garner as much training value and learning value out of this as we can. And we've willingly accepted that responsibility.

MEMBER ROSEKIND: Great transition because we're going to go to Chief Whitaker. Could you give us any sense, briefly -- lesson learned for the industry, which is what the Chief was just saying, basically. You know, how -- what are the mechanisms available in the industry to make sure that everybody gets to learn from this experience?

CHIEF WHITAKER: Well, the group I represent now, the Aircraft Rescue Fire Fighters Working Group, you know, represents over 500 airports internationally. And we do take those lessons learned from each of the different incidences, whether they're large or small type incidences, and try to put them in -- and bring in conferences, presentations. We do three or four of those type of events a year. We work with other partners, FAA, NTSB, AAAE, other organizations to film and document those presentations and lessons learned and try to do regional outreach with the training academies.

MEMBER ROSEKIND: Great.

I have the last two quick questions for FAA. I didn't know if I could ask this, but Mr. Gardlin you showed a slide about the decrease in accidents. So one of the challenges everyone seems to have is you keep pushing more and more for safety, but because the accident rate is going down the numbers for the cost-benefit justification gets to be harder and harder.

FAA, you two guys, anything to say just about what those challenges are? And you talk about what's next, well, how are we going to get there given how -- it's a bit of an irony there, the safer you get the harder it is to make it even safer. Comment?

MR. GARDLIN: You're correct.

(Laughter.)

MEMBER ROSEKIND: Okay. The last question is, during the day here we've been talking a lot about human factors and human performance. And I think it's kind of interesting we've been talking about all the great advances in the technology, if you will, of occupant protection and firefighting.

What about the human factors part of the survivability here: wear your seatbelts, listen to the safety briefing, know where the exit is? You know, is there work going on or changes or advances in that, kind of, human part of this?

MR. GARDLIN: Yeah, there is, in fact. And we have -- another part of the Civil Aerospace Medical Institute looks at exactly those things. And one of the things that we're focusing on right now is improved and more effective ways of communicating safety information to people so that they actually assimilate it and it becomes second nature. So, yeah, it's an ongoing activity.

MEMBER ROSEKIND: And I know you're all familiar with our Most Wanted List. It's 10 items and fire safety is on there. January 16th we'll be announcing the 2014. So, I was in Philadelphia at that meeting, and I just want to acknowledge that I think there's a tremendous amount not only of acknowledgement, but congratulations for really the several decades' worth of advancements you've made, that we can be in a room now really talking about how those advances have really made a difference in saving lives and preventing injuries.

And as tragic as the accident is, part of the lessons learned is, believe it or not, acknowledging how much what you folks have done has made a difference. And I think -- my last slide was, what's next? And I think that's a challenge for you folks whether it's on the first response or on the prevention side, what's going to be next to see how we reach that next level. So, thanks to all of you for that.

CHAIRMAN HERSMAN: Vice-Chairman.

VICE CHAIRMAN HART: Thank you. I'm going to follow along the line of lessons-learned questioning that Member Rosekind started and ask the same question of the FAA as the regulator and Boeing as a manufacturer. This is obviously a very rare event, thankfully. And were there any lessons learned for either of you in your respective capacities from this event? Start with the FAA.

MR. GARDLIN: I think at this point the fact that the investigation is still underway and there's a lot of details that are not completely finalized, I probably would reserve judgment on what lessons we've learned. But certainly the impact sequence was not something that we've seen before, and so that's something that I think, you know, we'll have to consider the nature of impact sequences a little bit.

VICE CHAIRMAN HART: Okay. Thank you. We'll stay tuned for that.

I guess, Boeing, you may be saying the same thing, but I'd be interested in hearing your response?

MR. WALLACE: Yes, it is the same answer. As you know, in our previous discussions, that these kind of events, working with the NTSB, the FAA, and the other people involved in this, we do learn things when we have an accident. This one was very severe, but we expect -- the investigation is ongoing, and certainly once we kind of conclude to this, there'll be an opportunity to see if there's any areas for improvement.

VICE CHAIRMAN HART: Okay. Thank you.

That's all I have. Thank you very much for your participation.

CHAIRMAN HERSMAN: I have a question about the different types of seats that were in the 777 involved in this accident. We had three-point belts in the first class or business section versus two-point belts back in the economy. Is there a difference with respect to passenger protection or survivability when it comes to those two seating configurations? Boeing could take that, if you'd like.

MR. WALLACE: So, as has been discussed here, one thing is that the business class seats themselves were installed after delivery for us, so we don't know the details of the design or anything. But in the business class, as Rick was pointing out, there may be some orientation of the seats or some extra obstacles in the way that would require them to have a shoulder harness. And we do this so that we can provide the same safety benefit that we're getting in the economy section as far as meeting the criteria and the safety standards that we have.

CHAIRMAN HERSMAN: Okay. So the bottom line is both seats are required to meet the same criteria?

MR. WALLACE: That is correct.

CHAIRMAN HERSMAN: Okay. What do we know about the seatbelt use rate for passengers on aircraft and the compliance?

Did we have any passengers in this flight who we know were not wearing their seatbelts or who we suspect were not wearing their seatbelts?

MR. WALLACE: Yeah, there were some interviews with some passengers that indicated that persons were not wearing their seatbelt, and another one had indicated that there was a blanket over their lap so they didn't know.

CHAIRMAN HERSMAN: Okay. So, Mr. Wallace, I think with those interviews what we're talking about is we're talking about some of the fatalities. And so, maybe we could be a little bit more clear about that because those interviews are available.

So we had one of the fatalities that there was the possibility that they weren't wearing a seatbelt because they were covered with a blanket?

MR. WALLACE: That is correct.

CHAIRMAN HERSMAN: And the other one was confirmed not wearing their seatbelt?

MR. WALLACE: That was the response from one of the other passengers, yes, correct.

CHAIRMAN HERSMAN: Okay. And the area where we saw the fatalities, the fatal passengers, what part of the aircraft was that?

MR. WALLACE: They were in the very aft, Row 30 -- or Row 41 and 42.

CHAIRMAN HERSMAN: And that was where the most significant structural damage to the aircraft was?

MR. WALLACE: That is correct.

CHAIRMAN HERSMAN: Okay. I would like to move to Assistant Deputy Chief Carnes. You had a presentation that you provided to -- 6-V. And in your presentation you listed successes and challenges. And if I could get the page that references the challenges pulled up?

There was a major issue with respect to the on-scene response. There was a passenger who was run over. And so, can you -- when I look at the challenges section, I was surprised not to see something with respect to how you dealt with that. So maybe that's contained within one of these other areas?

CHIEF CARNES: We do, in fact, consider that's a challenge, ma'am, and we actually do reference that we are working on developing strategies to limit the potential for firefighting vehicles striking or impacting accident victims.

CHAIRMAN HERSMAN: So along the lines of lessons learned, kind of help me understand in your post-incident, post-accident review what your determination was. Certainly part of what we're doing here is educational for other firefighting communities around the country at different airports. What were some of the lessons learned for you all that came out?

CHIEF CARNES: Well, one of the lessons learned is that there does not appear at this time to be an industry standard or best practice on limiting or avoiding secondary strikes. We have reached out to multiple other ARFF agencies, other NFDC chiefs. We are currently continuing to pursue that, and also work with our coroner's office.

You know, every -- ma'am, every ARFF incident is different and unique, and they're very complex. You're dealing with very large apparatus that are required to get in very close to a burning aircraft in order to do their job and facilitate rescue. It's a situation where it's a very complex situation. And whatever solution we come up will be multi-layered and will be situationally dependent. We'll have to be flexible enough to deal with the multiple types of scenarios we face within the ARFF community.

CHAIRMAN HERSMAN: Are there specific procedures for marking victims that are found in a debris field?

CHIEF CARNES: In this case, it was a matter of my personnel recognizing that they had an obviously deceased victim, and based on their training and their experience making that recognition. At least three of my firefighters independently made the same observation, and each of the personnel that recognized the deceased, then immediately -- based on their training and our protocols, defaulted to the higher priority of effecting rescue of trapped victims in a burning aircraft.

With 23 personnel on scene, and again, having trapped -- multiple trapped victims inside the aircraft, even if we had a system to mark the deceased, it would have been -- it wouldn't have been appropriate to take the time to do that at that point. They had to default to the rescue in order to prevent further loss of life.

CHAIRMAN HERSMAN: And I think we all appreciate the work that was done. There were 300 people that walked away. There was a lot of successes here. And I think when you all talked about triage, it was doing the most good for the most people in the shortest amount of time. But I think certainly in this case there was -- there's one person who didn't get the treatment that I know that you all would want, and that we would expect in the situation. So understanding what happened, I think is important for all of us.

These are big apparatus. You talked about limited visibility in difficult conditions. What are some of the ways that this type of event could be prevented? Are we talking about spotters or visibility cameras to see more? What are we talking about here?

CHIEF CARNES: Again, we already had a spotter. We refer to our second and third personnel on our ARFF rigs as riders. Their responsibility is to work as a second set of eyes and also work as a ground guide when needed, and certainly you can see that in some of the footage from the -- from our cameras on our vehicles. However, because, again, of the pressing need to extricate trapped victims from the aircraft, our riders were eventually pressed into service inside the aircraft leaving our drivers by themselves.

If I may for a moment, let me put you in the cab of one of our rigs in that environment. You're talking about, again, a very dynamic and complex environment. You're having to maneuver your apparatus very close to the aircraft. You're not only responsible for driving that apparatus, but you're carrying out a very technical multi-faceted operation operating your high reach extendable turret, your nozzles, delivering your agents appropriately. And even though we do have cameras, I can honestly tell you that as the operator your focus is on the task at hand and supporting your crews on the inside and delivering the agent and maneuvering up close to that aircraft.

So I think that this was -- while we definitely regret the additional insult to the deceased -- and I can attest that as professional rescuers every life to us is critical -- this is a matter of, certainly not of us being careless or callous, either one. It was the fact that we were dealing with a very complex and dynamic environment and we were very much focused on the priority at hand, and that was saving as many lives as possible.

CHAIRMAN HERSMAN: Thank you. I think we certainly understand that in any post-accident crash environment where you've got a lot of victims, survivors, people who are injured, is going to be very dynamic. And so, I think our interest here is just making sure that we learn the lessons and make sure that we share them with the community. So, thank you.

CHIEF CARNES: We agree.

CHAIRMAN HERSMAN: Are there additional questions from the parties? From the tech panel?

Oh, I'm sorry. I'm sorry, Captain Kim did you have a question? Oh, no questions.

MR. LeBARON: We have none.

CHAIRMAN HERSMAN: Mr. LeBaron? No further questions from the Board Members? Very well.

I think since we have no other witnesses to testify, the NTSB's investigative hearing into the crash of Asiana Flight 214 at San Francisco International Airport is concluded. The record will remain open for additional materials requested during the hearing.

On behalf of my fellow Board Members and all of the NTSB staff, we extend our appreciation to all of the participants at the hearing. I thank each of the witnesses for their testimony and the parties and the party spokespersons for their cooperation, which is essential to all aspects of our investigation. And it was particularly evident here at this hearing today with all of the diverse and willing participants.

I'd like to acknowledge the staff from the NTSB's Office of Aviation Safety, and the support of the staff from offices across the NTSB.

The transcript is scheduled to be available to the parties and the witnesses electronically within 7 days. Any corrections to the transcript by the witnesses or the parties should be sent to the Hearing Officer, Mr. Tim LeBaron, within 30 days of receipt of the transcript, which should be on about January 18th, 2014.

Any documents or information identified during the hearing that a party agrees to furnish to the NTSB should also be provided by that same date, January 18th, 2014, to our Hearing Officer.

The archive of the hearing webcast will remain on the NTSB website. That webcast will also be archived in Korean and Mandarin as well.

The transcript of the hearing and all of the materials entered into the record will become part of the public docket along with all of the other records of the investigation.

Today we have shined a valuable light on the facts and the circumstances of July 6th. Our investigation is ongoing and we will continue to work diligently to finalize our report.

Commercial aviation has never been safer than it is today. And we owe many of the advances in aviation safety to advances in cockpit automation; however, automation must be well understood and monitored effectively by flight crews. Today's hearing has provided our investigators with valuable insight about the specifics of the 777 flight deck, Asiana crew training, and automated systems.

While we seek to understand how the three passenger fatalities and serious injuries to all on board might have been prevented, we also want to identify the factors that contributed to saving the lives of more than 300 passengers and crew members. Today's testimony has also provided valuable information about crashworthiness and emergency response.

More and more we recognize that aviation is an international endeavor and we are both dependent and strengthened by our relationships around the globe. Fortunately, we do not have accidents like Asiana 214 very often. But when we do, we are obligated to investigate them, to learn from them, and to determine actions that can be taken to prevent them from occurring in the future. While each witness and each organization represented here brings different knowledge to the table and has a different perspective, everyone here has the same goal: to improve aviation safety.

Despite the disruption with yesterday's closure, I would like to recognize everyone who made this hearing possible, our NTSB staff that coordinated a multitude of logistical challenges in a very short time frame, and I have to take my hats off to the interpreters who have a tough task under normal conditions, but under a long day like today, I believe their challenges were doubled. I would like to acknowledge the more than 20 witnesses who accommodated the late change in schedule and came well prepared to testify.

And finally, I would like to recognize Chairman Cho for making the long journey here from Korea to attend this hearing. His effort to travel and be here in person is a testament to the great cooperation among our foreign partners and the shared desire to make aviation safer.

We stand adjourned.

(Whereupon, at 7:47 p.m., the hearing in the above-entitled matter was adjourned.)

CERTIFICATE

This is to certify that the attached proceeding before the

NATIONAL TRANSPORTATION SAFETY BOARD

IN THE MATTER OF:	INVESTIGATIVE OF THE ASIANA AIRLINES FLIGHT 214 LANDING ACCIDENT AT SAN FRANCISCO INTERNATIONAL AIRPORT, CALIFORNIA, July 6, 2013
PLACE:	Washington, D.C.
DATE:	December 11, 2013

was held according to the record, and that this is the original, complete, true and accurate transcript which has been compared to the recording accomplished at the hearing.

Edward Schweitzer
Official Reporter